UNESCO

# The Courier

FEBRUARY 1966 - 8 French francs

## THE NEW WORLD OF THE OCEAN

# A time to live...

## 42 Benin

**Village on stilts**

In Ganvié, a lagoon village in the coastal region of Benin, dugout canoes ply between thatched-roof dwellings built on piles in the water. One of Africa's smallest States, Benin consists of a long wedge of territory extending some 675 kilometres from the Niger, which forms part of its northern frontier, to the Atlantic where it has a 125-kilometre seaboard. The land rises from the narrow coastal strip to a swampy, forested plateau and then to highlands in the north. With an estimated population of some 3.5 million, most of whom live in the hot, humid southern third of the country, Benin takes its name from a kingdom that flourished in the West African forest region between the 14th and 17th centuries.

Photo © Hoa-Qui, Paris

UNESCO
# The Courier
A window open on the world

## Editorial

February 1986
39th year

FUELLED by the sun, the ocean is the powerhouse of the earth; the source of all life, it is a huge heat exchanger that regulates our climate, it is a source of food, minerals and energy, it offers the cheapest form of transport available to us, and, last but not least, with its restless, ever-changing beauty it seems to have been designed for the delight of mankind.

Today, scientists and world leaders are looking more and more to the ocean from which we came as a reserve from which to meet the needs of a growing world population. If the potentially huge resources of the ocean are to be properly exploited for the benefit of all mankind, a major international co-operative effort involving scientific research, economic assessment and the institution of acceptable control mechanisms is required. It is with these problems that this issue of the *Unesco Courier* is chiefly concerned.

In all this Unesco has a major role to play. For years Unesco's Marine Sciences Division has been working to strengthen the research institutions and training capability of developing countries through programmes such as COMAR (Major Interregional Project on Research and Training leading to the Integrated Management of Coastal Systems). The Intergovernmental Oceanographic Commission (IOC), founded twenty-five years ago under the aegis of Unesco, has been concerned with such tasks as the planning, promotion and co-ordination of co-operative international research, for example, in the fields of ocean dynamics and climate, and the preparation of the General Bathymetric Chart of the Oceans. With the adoption in 1982 by the General Assembly of the United Nations of the Convention on the Law of the Sea, the responsibilities of the IOC are destined to be greatly increased.

It is a startling fact that in many respects we know more about the moon than we do about the vast mass of water that covers over two-thirds of the surface of our planet. Now more than ever before the time is ripe for a combined international exploration of "the last frontier".

**Front Cover:** Earth, the "Blue Planet", photographed from Apollo 11, the spacecraft that first took men to the moon.

**Back Cover:** Detail from a relief map of the ocean floor showing the huge expanse of the Pacific Ocean

**Editor-in-chief :** Edouard Glissant

Photo Drachoussoff © A.A.A. Photo, Paris

**4 Blue planet**
Unique in the solar system, only the earth has rain, rivers and oceans
*by Howard Brabyn*

**7 The restless currents**

**8 A fortune on the sea bed**

**9 Time and tide**

**11 Charting the ocean floor**
*by Dale Krause and Jacques Richardson*

**14 A world map of the sea depths**

**16 Glossary**

**18 The nature and purpose of marine science**

**23 Satellites scan the ocean**
Modern technology in the service of oceanography
*by D. James Baker*

**26 Twenty-five years of research**
The Intergovernmental Oceanographic Commission

**28 The challenge of the new ocean regime**
*by Mário Ruivo*

**30 Highlights of the Convention on the Law of the Sea**

**32 Living treasures of the deep**
Marine flora and fauna can provide food, medicines and information about the origins of life
*by Vitali Voitov*

**34 World fisheries face growing demand**

**37 Year of peace: 2**

**2 A time to live ...**
**BENIN: Village on stilts**

Published monthly in 32 languages by Unesco
The United Nations Educational, Scientific and Cultural Organization
7, Place de Fontenoy, 75700 Paris.

English, French, Spanish, Russian, German, Arabic, Japanese, Italian, Hindi, Tamil, Hebrew, Persian, Dutch, Portuguese, Turkish, Urdu, Catalan, Malaysian, Korean, Swahili, Croato-Serb, Macedonian, Serbo-Croat, Slovene, Chinese, Bulgarian, Greek, Sinhala, Finnish, Swedish, Basque, Thai

A selection in Braille is published quarterly in English, French, Spanish and Korean

ISSN 0041-5278
No 2 - 1986 - CPD - 86 - 1 - 431A

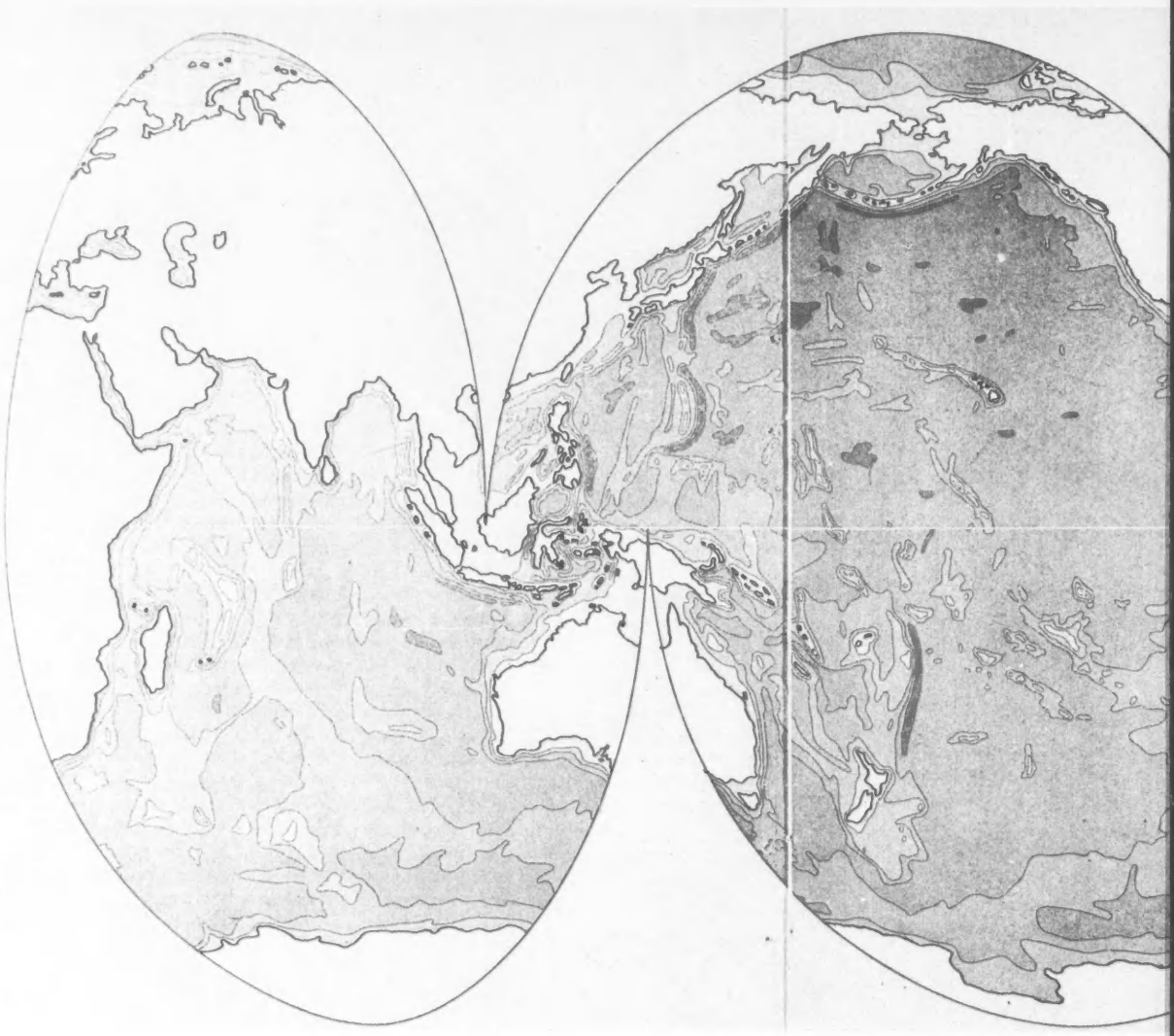


Photo © Scientific American, New York

# *Blue planet*

***Unique in the solar system, only the earth has rain, rivers and oceans***

***by Howard Brabyn***

***The enormous surface area of the world ocean is revealed by this map, known to map-makers as a homolographic, equal-area projection.***

OUR ancestors made a major, if understandable, mistake when they named our planet "Earth". They believed that, with the exception of some comparatively small bodies of water such as the Mediterranean and the Black Sea, the surface of our world consisted almost entirely of rocks and soil.

They knew, of course, of the existence of other waters but believed them to be part of the river Oceanus which encircled the world and from which sprang all other rivers and seas. Even as late as the sixteenth century, the great Flemish geographer Gerardus Mercator (1512-1594), the father of the science of cartography, believed that the earth was about equally divided between land and water and that there was a vast undiscovered land mass in the southern hemisphere to balance the great expanses of Europe, Asia and North America that lie within the northern hemisphere.

The Ancients would have been astounded to learn that water covers 70.8 per cent of the surface of the earth and to see the satellite photographs that confirm the excited words of twentieth-century astronauts as they watched the wonder of earthrise from the arid, barren expanse of the moon: "Our planet is blue! Our planet is beautiful!"

The earth, in fact, is uniquely favoured among the planets of the solar system. It alone has a surface temperature that permits water to exist in all three forms—liquid, solid and gas; it alone, as far as we can tell, has rain, rivers and oceans. To be strictly accurate we should say ocean, since what geographers conventionally define as the Pacific, Atlantic, Indian, Arctic and Antarctic oceans in fact constitute a single body of salt water from which the continents emerge like islands.

This vast, endlessly churning volume of liquid was the source of life on earth and remains essential to its continued existence. Acting as a huge heat reservoir it moulds our climate, levelling out the extremes of temperature that would otherwise prevail over the earth, creating deserts and frozen wastes. It is a major source of food and a potential source of valuable minerals and energy. It is a highly efficient waste disposal unit and provides the least expensive form of transport known to man. Its margins are mankind's favourite playground and its grandeur and beauty have inspired poets throughout the ages.

Nobody really knows for certain how the oceans were formed. Some scientists believe that the water came from thick clouds that surrounded the earth and that, as the earth cooled, rain fell from the clouds in a continuous downpour lasting hundreds of years. However, the newly-formed earth of 4,500 million years ago was very different from the earth we know today. It may have been a much larger planet with a molten core of rock and a vast atmosphere of cosmic gases. Because such volatile gases as neon and xenon are extremely rare in our present atmosphere as compared with the cosmic mix, it is generally thought that this early atmosphere was stripped away, perhaps during a period of higher heat output from the sun, and that our present atmosphere and surface waters derive entirely from the earth itself.

However, if water, which has a molecular weight of eighteen, which is less than the atomic weight of neon, had been suspended in the atmosphere, it too would have been swept away. Many scientists therefore believe that the water must have been tied up in compounds, perhaps hydrated silicates, until the earth had formed. Water would then have been released in liquid form as the rocks cooled some time during the first thousand million years of the earth's history.

Although we may still have doubts about its origin, we have learned a great ▶

deal about the ocean of today. The statistics are impressive. It has a volume of 1,370 million cubic kilometres and a surface area of 361 million square kilometres. It accounts for just under 98.8 per cent of the total hydrosphere, the remainder being made up of ice (1.2 per cent), and water in rivers and lakes (0.002 per cent) and the atmosphere (0.0008 per cent).

The average depth of the ocean has been estimated at 3,790 metres, considerably greater than the average elevation of the land above sea level, which is 840 metres. The point of maximum depth of the ocean is to be found in the Mariana Trench, between the islands of Guam and Yap, some 11,000 metres below the surface of the Pacific. If Mount Everest were to be placed in the Trench, its summit would be about two kilometres below the ocean surface.

Locked up in all this water is a great variety of salts and minerals in solution. In fact, sea water contains all the elements that make up the minerals in the earth's crust. At one time it was thought that the salinity of the modern ocean was due to salts derived from rock weathering and transported to the ocean by rivers. This would mean, however, that the salinity of the ocean was steadily increasing, whereas calculations have shown that the ocean probably acquired its modern characteristics between 1,500 million and 2,000 million years ago and that, for at least 100 million years, the oceanic system has been in a steady state with a fixed chemical composition. This implies that inflow and outflow of elements must be basically in equilibrium and that dissolved elements carried to the ocean in rivers and in rain must precipitate from ocean water or be cycled back through the atmosphere by evaporation to fall on the continents.

The atmosphere and the ocean are inextricably linked. The wind, in combination with the heat of the sun and the rotation of the earth, powers the mighty ocean currents, moving huge volumes of water in giant whirlpool motions that rotate clockwise in the northern hemisphere and anti-clockwise in the southern hemisphere (see box page 7). These currents carry staggering amounts of water. It is estimated, for example, that the Gulf Stream, an "ocean river" some eighty kilometres wide and 450 metres deep, propels more than 4,000 million tons of water a minute.

Movement of deep-ocean waters is governed primarily by variations in temperature and salinity. Cold water is heavier than warm water because it contracts as it cools (although, unlike other liquids it expands when it solidifies into ice) and tends to sink. Salt also makes water heavy and although salinity in the

CONTINUED PAGE 9

## The composition of sea water

The constituents of sea water include dissolved inorganic substances (mineral salts), dissolved gases and dissolved organic substances. Water is, in fact, the most powerful solvent of all liquids and all the natural elements can be found in sea water. The most common of these elements are chlorine (55 per cent) and sodium (31 per cent) which combine in the ocean to form sodium chloride—common table salt. Of all these elements only sodium chloride, magnesium and bromine are at present being extracted in significant amounts.

In the open ocean the salinity of water varies only between very narrow limits, average salinity being about thirty-five parts of salt to a thousand parts of water.

There are two rather curious parallels between sea water and the liquids of the human body: the ocean covers 70 per cent of the surface of the globe—70 per cent of the human body consists of water; a comparison of the composition of sea water and human body fluids shows that the proportions of the elements are largely the same.

**57 OF THE ELEMENTS THAT MAKE UP THE "SALT" OF SEA WATER"**
(In order of their abundance)

| | | | |
|---|---|---|---|
| Chlorine | Lithium | Uranium | Cadmium |
| Sodium | Rubidium | Nickel | Tungsten |
| Magnesium | Phosphorus | Vanadium | Xenon |
| Sulphur | Iodine | Manganese | Germanium |
| Calcium | Barium | Titanium | Chromium |
| Potassium | Indium | Antimony | Thorium |
| Bromine | Zinc | Cobalt | Scandium |
| Carbon | Iron | Cesium | Lead |
| Strontium | Aluminium | Cerium | Mercury |
| Boron | Molybdenum | Yttrium | Gallium |
| Silicon | Selenium | Silver | Bismuth |
| Fluorine | Tin | Lanthanum | Niobium |
| Argon | Copper | Krypton | Thallium |
| Nitrogen | Arsenic | Neon | Helium |
| | | | Gold |

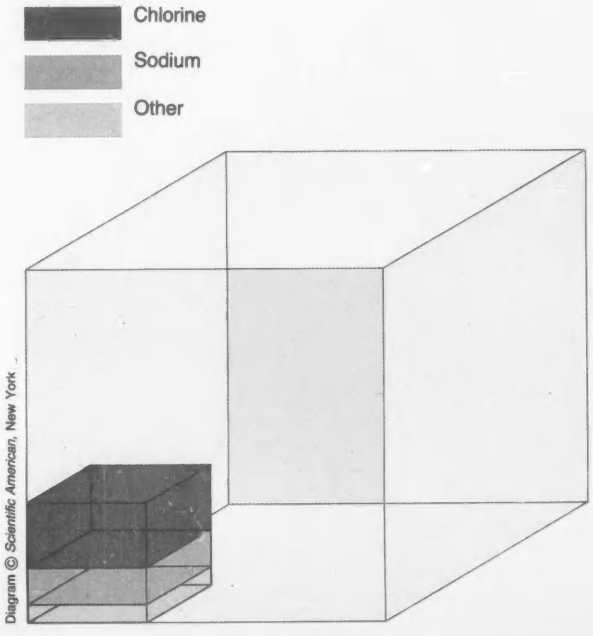



Diagram © Scientific American, New York

Photo Drachoussoff © A.A.A. Photo, Paris

# The restless currents

The waters of the ocean never stop moving. Most of us think of this motion in terms of the waves and tidal movements that we can observe for ourselves whenever we go to the coast. Less immediately apparent to the casual observer, however, are the great ocean currents, well-defined streams that flow over parts of the ocean in never-ending cycles.

Ocean currents are caused by a combination of three major forces: the heat of the sun, the rotation of the earth and the friction-force of the winds.

As the earth revolves round the sun it rotates on its own axis in such a way that the direct rays of the sun strike the seas near the equator, heating them up much more than the polar seas. As the surface water at the equator heats up it expands, raising the sea level at the equator almost imperceptibly but enough to create a "slope". The water at the equator, therefore, tends to run "downhill" towards the Poles.

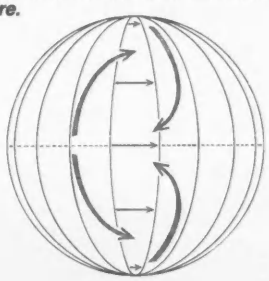
Cold water is heavier than warm water, because water contracts as it cools, and the colder water of the polar regions sinks beneath the inflowing warm water from the equator and spreads slowly back along the bottom towards the equator.

The rotation of the earth also has another curious effect on the waters of the ocean—and indeed on any moving object, such as a ballistic missile, an artillery shell, or even a ball that is thrown, although in the case of the ball its trajectory would be so short that the effect would be imperceptible. This "Coriolis effect" as it is called, after the French mathematician Gaspard Gustave de Coriolis who first described it, causes such objects to be deflected somewhat to the right in the northern hemisphere and to the left in the southern hemisphere.

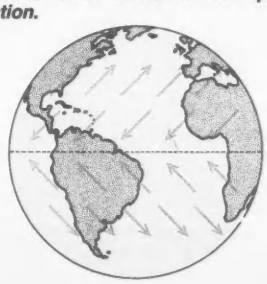
The winds too have a major influence on currents. The Trade Winds, which blow steadily from the north-east, in the northern hemisphere, and from the south-east, in the southern hemisphere, towards the equatorial regions, are the force which powers the great westward-moving currents just north and south of the equator. But these winds too are subject to the Coriolis effect which causes them to curve north and south away from the equator and to circle back in the higher latitudes, driving the surface waters before them from west to east.

The effect of all these factors combined is to set and keep in motion the gigantic eddies of circling waters that make up the main surface currents of the ocean.

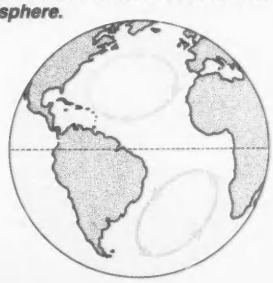
***Caused by the rotation of the earth, the "Coriolis Effect" deflects winds and currents to the right in the northern hemisphere and to the left in the southern hemisphere.***



***Also affected by the spin of the earth and by heat from the sun, wind belts drive the waters of the ocean; in the tropics the Trade Winds push them westward towards the equator, and in the higher latitudes the Westerlies drive them in the opposite direction.***



***A combination of three forces—the heat of the sun, the Coriolis Effect and the winds—causes the ocean currents to circulate clockwise in the northern hemisphere and anti-clockwise in the southern hemisphere.***



Diagrams taken from *The Sea* © Time Inc., New York

# A fortune on the sea bed

MANGANESE nodules occur mainly as a deposit in the deep sea. These potato-shaped concretions are rich in manganese oxides and are present on most of the floor of the deep ocean. However, their composition varies widely from place to place, and only in a few areas do they contain sufficient manganese, nickel, copper and cobalt, and other metals of possible economic value, to be of interest. A combination of about 13 per cent nickel, cobalt and copper, the most valuable metals, is regarded as making the nodules an economically viable resource.

The main area where nodules of this grade occur in good abundance is the north-eastern equatorial Pacific; this area has been the subject of most research work. However, nodules of similar composition occur in parts of the southern and western Pacific and also in the central Indian Ocean, where Indian research scientists are undertaking much work on them.

For a long time, high-grade nodules were thought to occur only at great distances from land, but exciting discoveries have been made recently within the two hundred-mile Exclusive Economic Zones of some of the small developing island nations of the South Pacific. These deposits belong to the adjacent islands themselves and, if they were commercially recoverable, the island peoples would benefit. This possibility has prompted the United Nations to set up a development programme to organize further exploration in these areas on behalf of the islands.

Another deposit, similar to manganese nodules, which has been receiving much attention recently in the Pacific, is the so-called cobalt-rich manganese crusts. The crusts are similar in their overall composition to manganese nodules but are richer in cobalt, up to 2 per cent, and lower in nickel and copper than the highest grade nodules. Cobalt is a strategically valuable metal and only a limited supply is available from mines on land, so these marine deposits may provide an alternative future source of the metal.

Unlike nodules, which lie loose on the sea floor, crusts occur as coatings on rock outcrops and can be up to several centimetres thick. They occur at much shallower depths than most nodules, which are richest below 4,500 metres, and the highest grade deposits are present at less than 2,000 metres deep. In the Pacific Ocean, depths of 2,000 metres are usually associated with seamounts, sunken mountains that rise from the deep ocean floor and which are often grouped into chains. Sometimes, one or more of these seamounts breaks the surface to become an island, and where this happens the deposits on the submerged part of the island and on adjacent seamounts within the two hundred-mile Exclusive Economic Zone belong to that island.

This discovery, like that of high-grade nodules near some islands in the Pacific, is stimulating a lot of work on cobalt-rich crusts. Nowhere is this more so than in the Hawaiian Islands, where the islands themselves are just the peaks at one end of a long submarine mountain chain stretching across more than 1,500 kilometres of ocean all the way west to Midway Island. ■

**David Cronan**
*Reader in marine geochemistry*
*Imperial College of Science*
*and Technology, London*
*Reproduced from a longer study*
*by courtesy of* New Scientist *magazine, London*

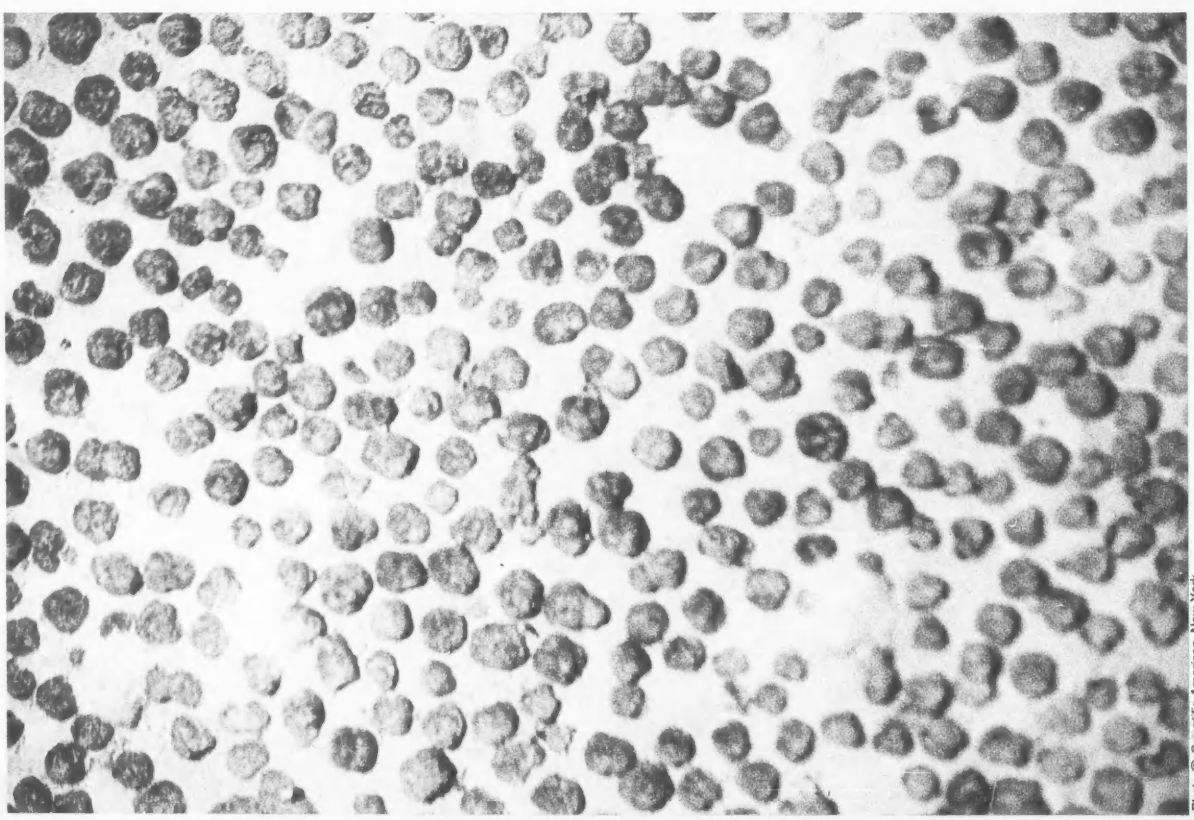


Photo © *Scientific American*, New York

# Time and tide

Tides, the periodical rise and fall of the waters of the ocean, are due to the gravitational pull of the moon and, to a lesser extent, of the sun. At most seaside places there are two tides a day, the average time interval between two successive high waters being twelve hours and twenty-five minutes.

When the moon is directly over any point in the ocean, it pulls the water towards it causing a "doming up" of water under the moon. On the side of the earth opposite to this point, however, the centrifugal force generated by the rotation of the earth will exceed the attractive pull of the moon, causing the water of the ocean to tend to dome outwards. Thus high tides will occur at the same time on opposite sides of the earth, rather than a high tide on one side and a low tide on the other.

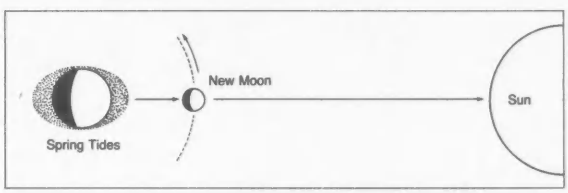
Low tides occur at points ninety degrees away because water is flowing away from these areas towards the areas of high tides. In other words, there is a horizontal flow from every point of the ocean towards the points directly under or directly opposite the moon.

The gravitational pull of the sun, which is less than half that of the moon, somewhat complicates matters. When there is a new moon, the moon is situated between the earth and the sun so the attraction of the sun and the moon reinforce each other. Two weeks later, when the moon is full, it has moved round to the opposite side of the earth to the sun so that the earth is between them and once again they are pulling on the ocean, this time in opposite directions but along the same axis. At these times the earth experiences its highest tides, commonly known as spring tides.

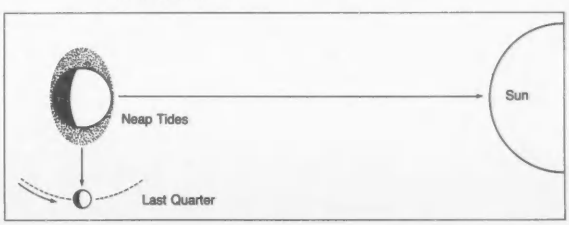
At the quarters of the moon, when the sun and the moon are at right angles to each other in relation to the earth, their respective gravitational pulls tend partly to counteract each other. At these times the tides, commonly called neap tides, are neither so high nor so low.

The moon travels in an elliptical orbit in relation to the equator, swinging back and forth over the northern and southern hemispheres. In some parts of the earth this inclination of the moon's orbit, coupled with the fact that the axis of the earth is tilted in relation to its orbit round the sun, produces diurnal tides (tides occurring at intervals of twenty-four hours and fifty minutes) rather than the semi-diurnal tides (tides occurring at intervals of twelve hours and twenty-five minutes) described above. Semidiurnal tides predominate in the Atlantic, whereas diurnal tides are found on the coasts of Alaska, the Philippines and China.

***At the times of new and full moon, the earth, the moon and the sun are in line and reinforce each other's pull on the oceans on earth, causing the spring tides—the highest and the lowest tides of the lunar month.***




***During the first and last quarters of the moon, the sun and the moon pull at right angles to each other, causing the neap or weak tides.***




Diagrams taken from *Exploring the Secrets of the Sea* © William J. Cromie

CONTINUED FROM PAGE 6

open sea remains fairly constant at around 3.5 per cent, water near freezing ice will be heavier because extra salt is left behind in the freezing process. As this heavier, saltier water sinks it begins to move along the ocean floor in the opposite direction to the surface current above it.

It is this mechanism that is responsible for the renewal of virtually enclosed bodies of water such as the Mediterranean where salinity is high due to high rates of evaporation. This increases the density of the surface water which sinks and begins to flow westwards through the Straits of Gibraltar and out into the Atlantic. Passing above this submarine current, lighter water from the Atlantic flows in to replace it.

The other great forces that act upon the movement of the ocean are the attracting force of the sun and the moon and the centrifugal force resulting from the orbital movement of the earth round the sun and the moon round the earth; these cause the rhythmic movement of the waters of the ocean which we call tides (see box this page). These same forces actually move the earth itself and the atmosphere as well, although the rise and fall of the continents is so small as to be imperceptible.

The ocean has a powerful effect on climate. Compared with the land, the ocean heats slowly in summer and cools slowly in winter, so its temperature is much less variable; because of its huge size it has a moderating effect on land and air temperatures and helps to iron out temperature extremes.

Curious as it may seem, the ocean floor is much younger than the ocean it underlies (the oldest sediments found so far by deep-sea drilling are from the Upper Jurassic period and are only about 150 million years old) and is continually being added to by extrusion of new, initially molten basaltic rock rising from the mantle. As the upwelling molten rock solidifies on reaching the ocean floor it is magnetized in the direction of the earth's prevailing magnetic field. Magnetic patterns are established which can be dated by reference to the time-scale of geomagnetic reversals which occur at irregular intervals of a few hundred thousand years. Our knowledge of the geology and topography of the ocean floor has made giant strides during the past twenty years, thanks largely to technological advances which have made possible improved bathymetric and submarine geological mapping (see article page 11).

The mineral resources of the sea bed, unlike those contained in the overlying waters, tend to occur in localized deposits on top of and within the rocks and sediments of the ocean floor. These potential ▶

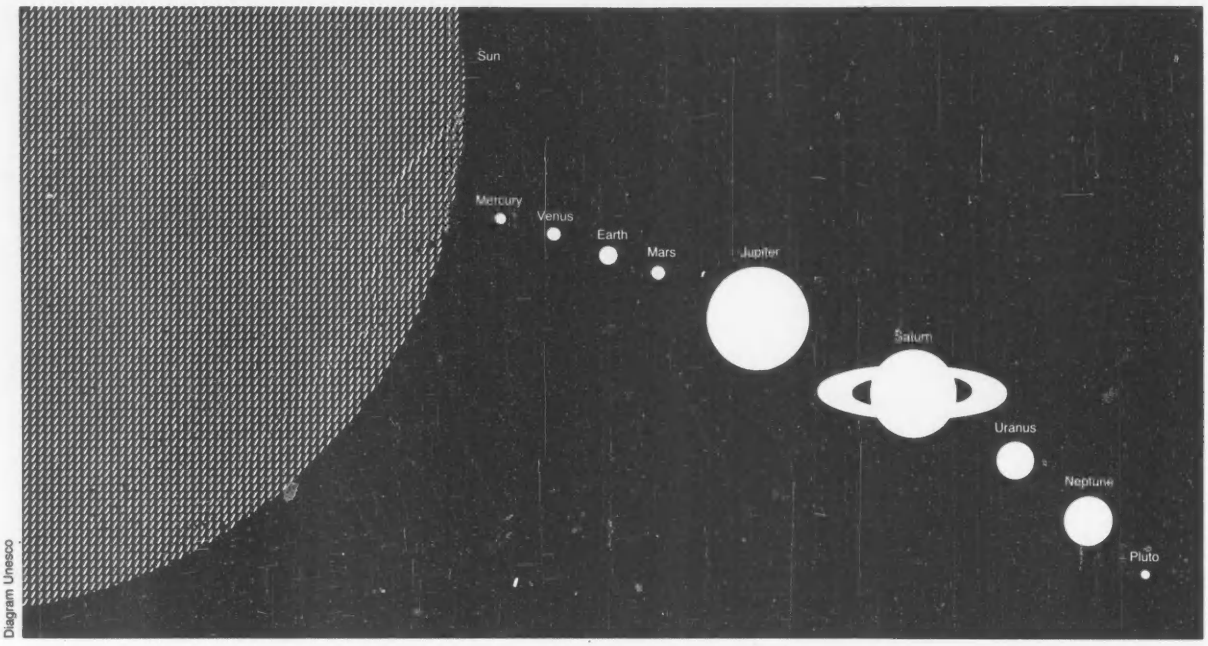



Diagram Unesco

***Relative sizes of the planets, arranged in order of distance from the sun (but not according to their respective distances from each other).***

▶ riches include: surface deposits such as heavy metals, diamonds, sand, oyster shell and gravel, and the much-publicized nodules of manganese and phosphorite that have formed by precipitation from sea water; subsurface deposits, such as coal and iron ore, which have been mined since as early as the beginning of the seventeenth century by tunnelling from the land; and fluid and soluble minerals, such as oil, gas, sulphur and potash, which are extracted through boreholes. At present oil and gas represent around 90 per cent in terms of value of all minerals obtained from the oceans. As recovery techniques improve this situation is likely to change rapidly and it was largely in an attempt to ensure an equitable share-out of what looks like being a new minerals bonanza that the United Nations Convention on the Law of the Sea was drawn up (see page 30).

Although all the chemical elements are present in sea water itself, only magnesium, bromine and sodium chloride (common salt) are now being extracted in significant quantities. The other resource which is increasingly being extracted from sea water is water itself—fresh water. Rising demand for fresh water and improvements in technology are making desalted water competitive in ever larger areas of the world.

The ocean is a provider of food to eat as well as of water to drink. Over the past decade total catch from the sea has averaged 75 million tons (see box page 34). Our present fishing methods, however, are inefficient. We overfish certain species to the point where they are in danger of complete extinction and reject others which are equally valuable as a source of protein. It has been estimated that with efficient harvesting of all the fish of the sea, the ocean could provide a sustained yield of around 2,000 million tons of food annually.

The Japanese in particular are actively developing methods of "fish-farming" which hold great promise. Fish will remain in an area convenient for fishing if a food supply for them is artificially created. For instance, by inducing upwellings of the nutrient-rich bottom layers of ocean water, similar to the naturally occurring upwelling that sustains the huge anchoveta fisheries off the coast of Peru, the potential yield of the ocean could be increased perhaps as much as tenfold.

The ocean's potential as a source of energy which can be harnessed to meet man's needs is still largely hypothetical. Only in a few places is it economic to harness the energy locked up in the world's tides. Only one large tidal power plant has been built—at La Rance, in France—and there are thought to be only about twenty-four potential tidal power sites in the world. Research is continuing on the extraction of the energy stored in waves, but this is still at the early experimental stage.

Greater hopes are placed in exploiting the temperature differential between the surface and the lower layers of the ocean to generate electricity by means of a process known as Ocean Thermal Energy Conversion. Experiments with this technique undertaken by French researchers have proved technically successful, but as yet the technique remains uneconomic in practice.

As man turns back again to the sea, the source of all life, in an attempt to draw even more heavily on its resources, he will have to tread warily if he is not to destroy it entirely. There was a time when we could dump into the ocean the sewage and other effluents and wastes from homes and industry safe in the knowledge that they would be rapidly dispersed, diluted and degraded. But with the rapid growth of world population and the concentration of people in coastal areas, both for industrial and recreational purposes, combined with the sheer bulk of the material to be disposed of and the inclusion in it of new, non-biodegradable waste products, this is no longer possible. Furthermore, lead in exhaust emissions from cars and wind-borne toxic DDT residues as well as agricultural fertilizers and pesticides of all kinds are finding their way into the ocean to add to the pollution from oil spills, from radio-active fallout and from dumped radio-active wastes.

The ocean has been called "the last frontier". We are rapidly acquiring the basic knowledge and the technology which will enable us to harvest the untold riches of the sea; with the Convention on the Law of the Sea we have the embryo of a legal and institutional framework within which to reap this harvest to the best advantage of all mankind and to correct past errors due to ignorance, neglect and greed. ■

**HOWARD BRABYN,** *of the United Kingdom, is a Paris-based writer and journalist with a special interest in the popularization of science. He was formerly Editor of the English edition of the* Unesco Courier.

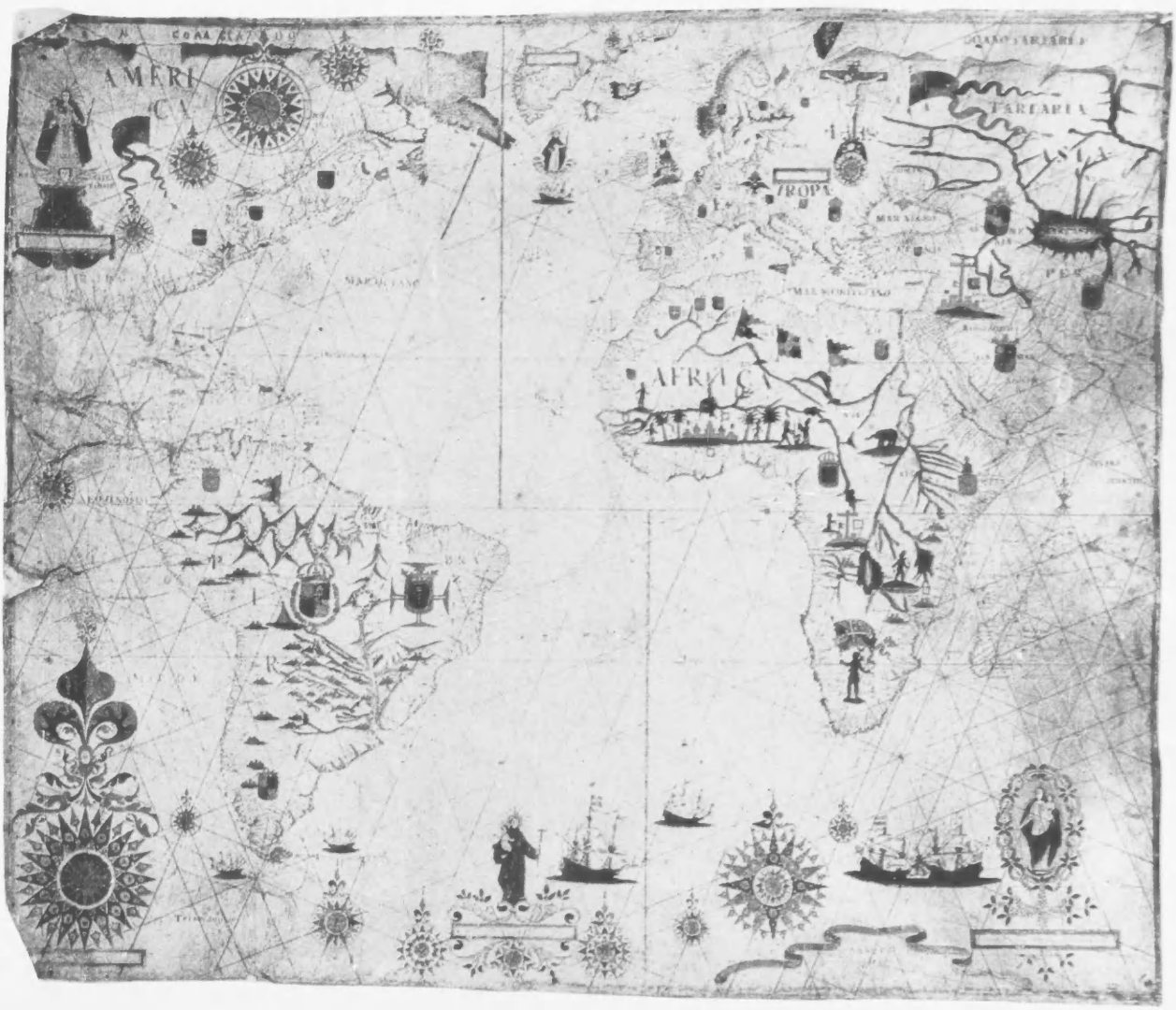
# *Charting the ocean floor*

*by Dale Krause and Jacques Richardson*

THE tale of Aeneas, legendary hero of ancient Greece and Rome, is one of hazardous voyages back and forth across the Mediterranean Sea, between the Eurasian land-mass and Africa. In his turbulent wanderings from Troy to Carthage to Latium (Italy), Aeneas is constantly in peril from the hidden dangers of travelling over deep waters. He loses his father, Anchises, as a result of intemperate weather inevitably attributed to the mystery of the ocean's depths. The sea is thus an enigmatic environment, threatening and incomprehensible.

And so it remained until the great marine explorations of the fifteenth to nineteenth centuries. Only relatively recently have we begun to understand, measure, evaluate and demystify what lies in the salty deep of the world ocean.

We now know that although our planet is made up essentially of soil, rock and sand (in either solid or molten form), ▶

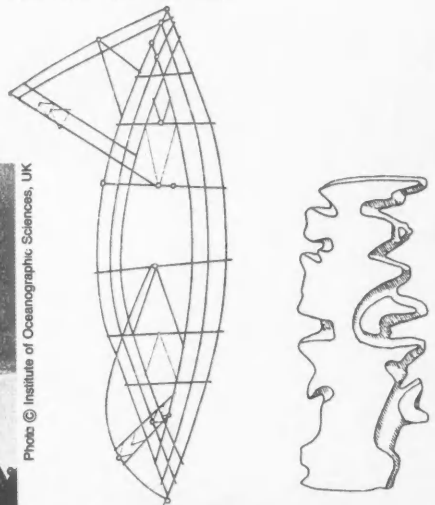



***Portuguese nautical chart of the Atlantic Ocean drawn on parchment by Pascoal Roiz in 1633.***

Photo taken from *The Drama of the Oceans* © Abrams, New York

***The earliest surviving European sea chart, the* Carta Pisana *(above) depicts the entire Mediterranean. It is hand drawn on a sheepskin and dates from about 1275.***

Photo taken from *The Drama of the Oceans* © Abrams, New York



***Peoples with no tradition of the written word used ingenious methods of producing navigation charts and maps. Drawings show (above left) a Micronesian navigation "chart" consisting of a lattice-work of sticks showing the relative positions of the islands of the Marshall Islands group, and (above right) an Eskimo "map" carved from wood recovered from the sea.***

Drawings taken from *Cartes et Figures de la Terre* © CCI, Paris

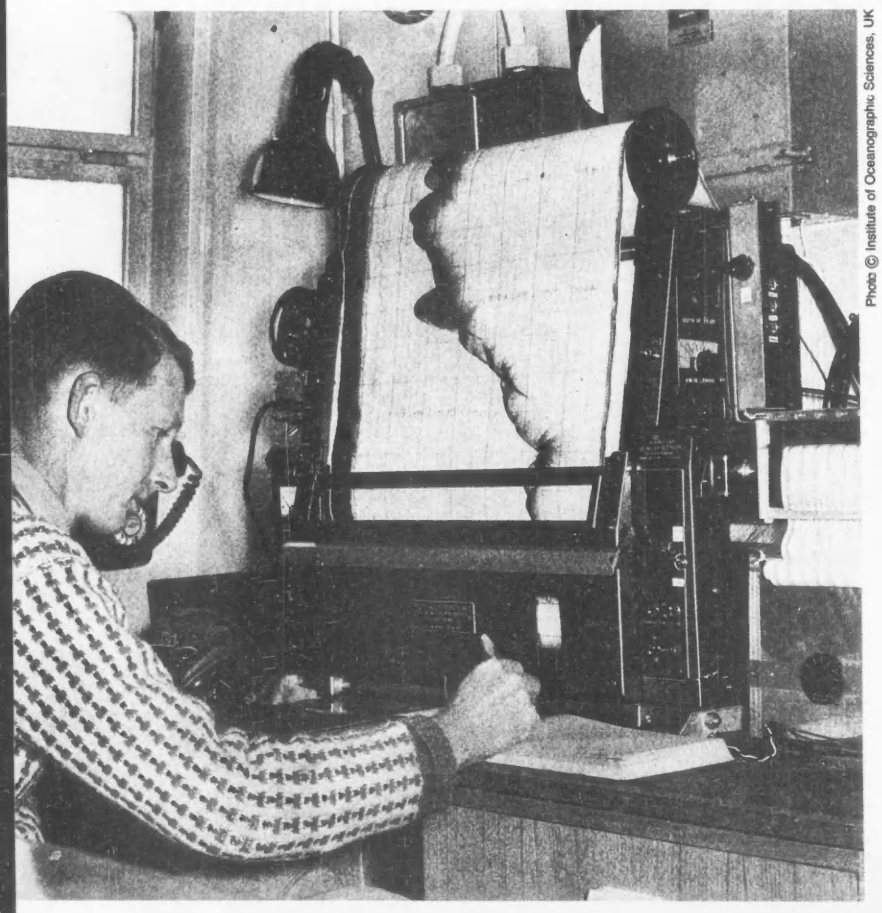


Photo © Institute of Oceanographic Sciences, UK

***Echo-sounders are used to chart the topography of the ocean floor. Left, a marine scientist at work at an echo-sounder recording unit aboard the British research ship* Discovery.**

▶ nearly 71 per cent of its surface is covered by the sea. Of the remaining 29 per cent of terrestrial or land formations, one-fifth of all the continents are submerged as "continental shelves". It may not seem significant at first glance that 20 per cent of the continents are under water, but this represents a territorial land-mass equal to that of Africa. This was not understood by the ocean's first users (prehistoric man and some of our less remote ancestors), who perceived a sheet of water as a joining or interruption of two or more pieces of land—unaffected by what lay beneath.

As man's activities in fishing, sailing and navigation, transport and the movement of navies became more far-ranging and complex, it became necessary to learn more about what lay beneath the water. The explorations of Phoenician, Indian, Chinese and Arab sailors produced the first simple maps of the ocean. The oldest existing chart of the sea, in the form of a clay tablet, dates from the Babylonian period of 4,500 years ago. The Micronesians, using twigs and shells, produced charts of the Pacific Ocean.

Gradually, our "road maps" of the sea, or sailing charts, became more detailed and complicated. Mariners recorded not only depths, but also the locations of obstacles such as large rocks, shoals and reefs. They noted local and regional currents, seasonal temperatures and salt content. They compiled atlases of the shapes of coastlines, islands, harbours, river estuaries and deltas, beaches and coastal vegetation, as well as catalogues of fish and other inhabitants of salt water. And when the first international meeting of hydrographers (mappers of the sea) was held in Belgium in 1853 to try to understand the effects of the ocean and weather on one another, it gave birth to the new science of oceanography.

But it was not until the undersea manoeuvres of navies during the principal wars of the twentieth century that curiosity and need drove governments, petroleum and mineral explorers, and universities to begin a systematic study of the shape and substance of what lies under the ocean's waves. Thus blossomed the disciplines of marine geology and bathymetry (measuring ocean depths) to provide the new knowledge that is indispensable if we are to use the sea intelligently and preserve its resources as far as possible for future generations.

The sea bed that was once thought to be flat is, we know now, anything but an endless plain. The continental slopes that drop gently from the continental shelves are marked nearly everywhere by submarine canyons, large troughs that have been eroded by dense currents of combined sea water and mud; these form as earth-slides at the tops of the canyons and wear away courses or paths much as sandpaper smooths down wood. Submarine earthquakes, modern volcanoes and eruptions of red-hot magma (lava) constantly shift the contours of the sea bed along the central ridges of the ocean basins.

Research carried out between the 1930s and the 1950s in the Pacific Ocean basin revealed hundreds of undersea mountains (called seamounts), mostly old volcanoes, measuring 3,000 metres or more in altitude above the floor of the sea. Some of these are shaped like cones with their topmost peaks missing; they are called guyots or tablemounts. These flat-topped ancient volcanic summits have had their tips worn away over time by wave action and they may rise to within 100 to 1,600 metres of the surface of the ocean. During the Cretaceous period (roughly 100 million years ago) they became inhabited by organisms similar to those that built shallow-water reefs—or masses of coral—in the Pacific, Caribbean and other oceans. The guyots, and seamounts in general, have sunk as the earth's crust beneath them has cooled.

Techniques used to measure depth began with "sounding"—using a fibre or wire cable marked periodically with metallic or other weights, dipped and raised continuously to estimate the surface-to-bottom distance. The method is unreliable because of the irregularity of the sea floor, movement of the ship and currents running beneath the surface of the ocean.

Echo-sounding and sonar, invented to meet naval needs during the two World Wars, use a pulse or beam sent mechanically or electronically from a vessel to the bed of the sea, where it is reflected and then recaptured by the emitting vessel. The total time elapsed during the pulse's round trip is translated into distance, giving a "fix" on the target of the sound signal. A chart is produced by this process so that a printed memory or record can be kept of the depths along the course fol-▶

## Main types of minerals on the sea floor

| Type of deposit | Materials or elements | Geological setting |
|---|---|---|
| Construction materials | Pebbles, quartz and carbonate sand, shells | Coast and shelf |
| Placer deposits (sand and gravel containing heavy metals) | Iron<br>Gold<br>Platinum<br>Tin<br>Diamonds<br>Rare earth elements<br>Zirconium<br>Titanium<br>and others | Coast and nearshore |
| Hydrocarbons | Petroleum<br>Gas | Mainly passive continental margins and certain basins |
| Hydrothermal ore deposits | Iron<br>Manganese<br>Copper<br>Zinc<br>Lead<br>Silver<br>and others | Fracture zones, spreading centres, certain basins |
| Manganese nodules | Manganese<br>Iron<br>Cobalt<br>Nickel<br>Titanium<br>Molybdenum<br>and others | Deep sea (4,000 metres) |
| Phosphorites | Phosphorus<br>Uranium<br>Rare earth elements<br>and others | Coastal (locally continuation of land resources) and nearshore: submarine plateaux |

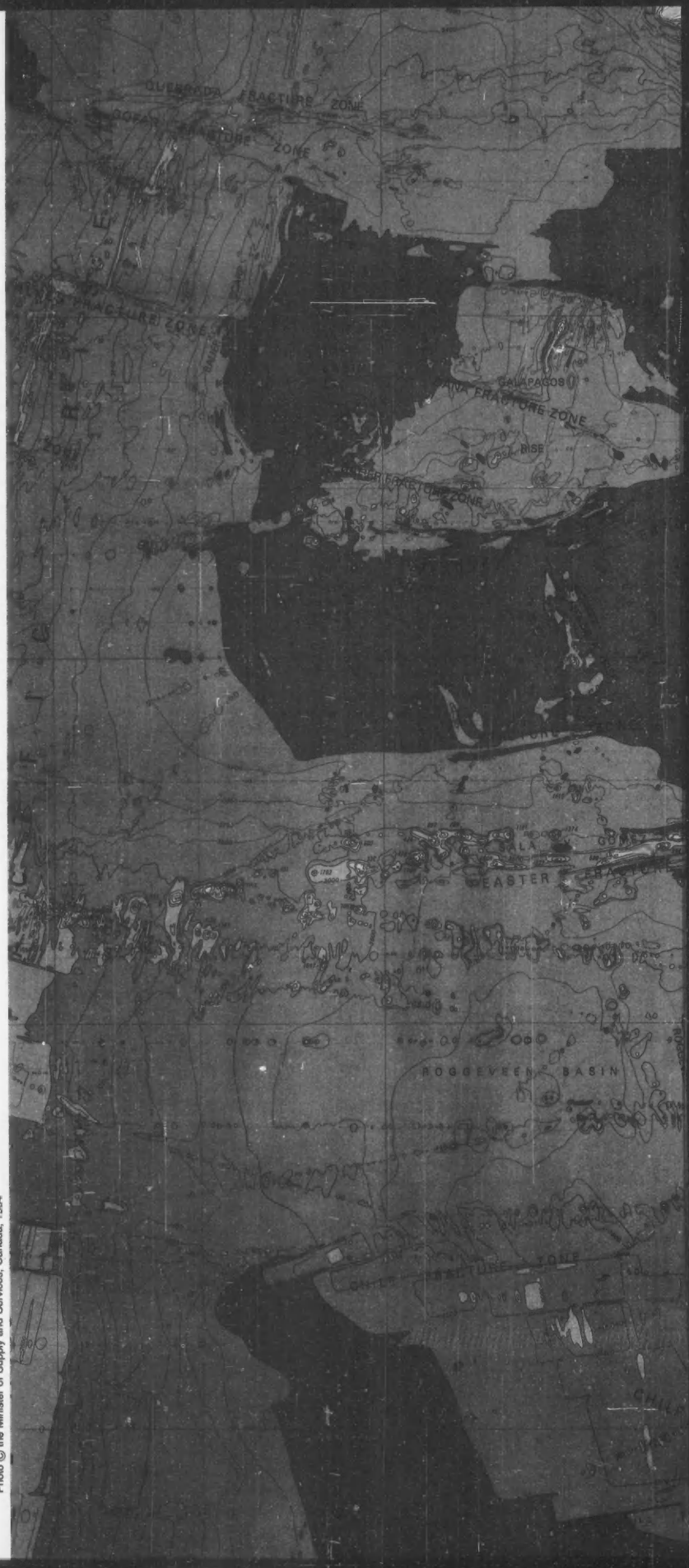
After P. Rothe, "Marine Geology: Mineral Resources of the Sea", *Impact of Science on Society*, Nos. 3 / 4, 1983

# A world map of the sea depths

The fifth edition of GEBCO (General Bathymetric Chart of the Oceans) consists of nineteen sheets. Sixteen of the charts cover the world from 72 degrees north latitude (at the northern tip of Norway) to 72 degrees south latitude (the Bellingshausen Sea of Antarctica), with a scale of 1:10 million at the equator. There are two polar sheets, or polar stereographic projections, of scale 1:6 million at 75 degrees latitude, and a world sheet reducing all the eighteen other sheets printed on the scale of 1:35 million. There is a guidebook for all these charts.

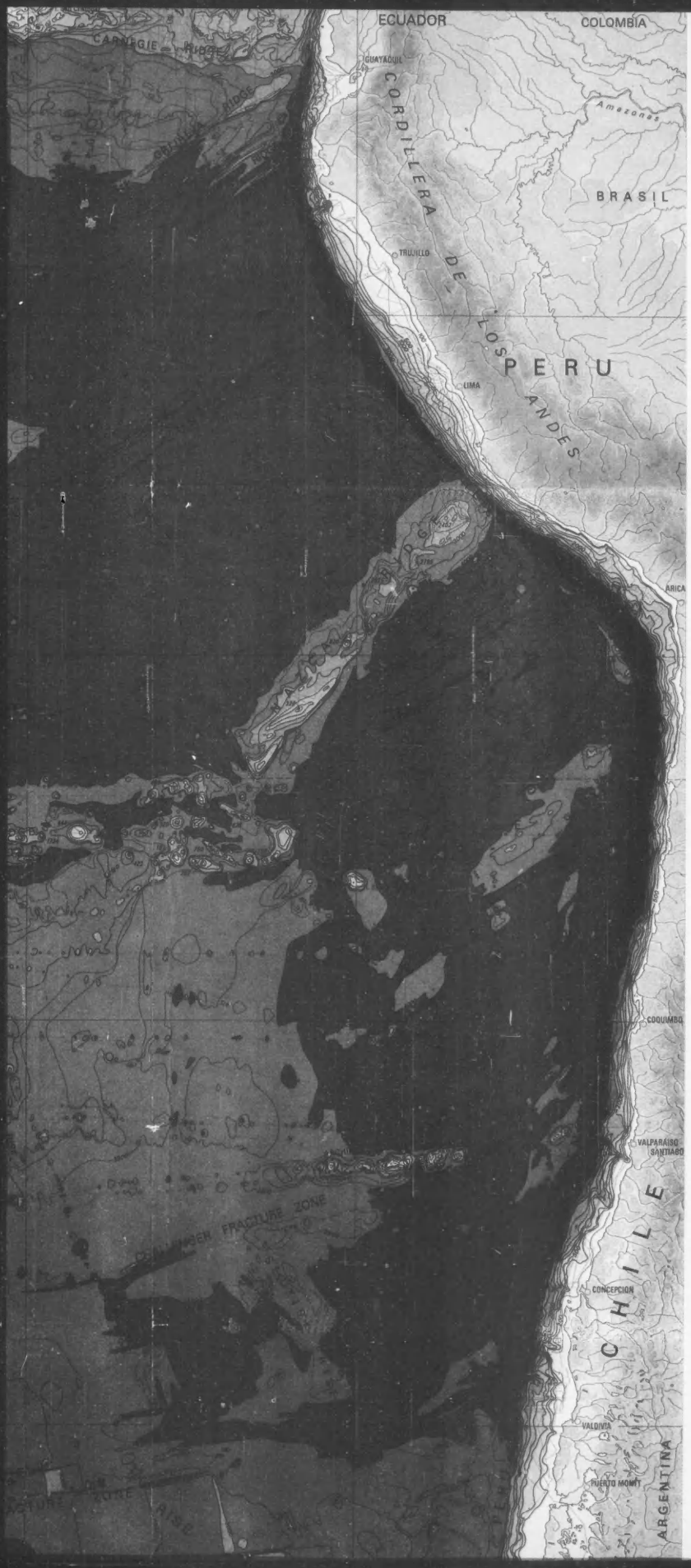
National hydrographic offices in eighteen Member States of the International Hydrographic Organization are responsible for upkeep of the basic data, a set of sixty-five "master sounding sheets". The Intergovernmental Oceanographic Commission at Unesco, together with three major non-governmental scientific bodies as well as the *French Institut Géographique National* and the Scott Polar Research Institute in Cambridge, are charged with providing the scientific details to be entered on the GEBCO charts.

Interested teachers, researchers, fisheries specialists and others may order the GEBCO series, boxed and accompanied by a supporting descriptive volume, at a cost of US $120 from: Hydrographic Chart Distribution Office, Department of Fisheries and Oceans, 1675 Russell Road (Box 8080), Ottawa K1G 3H6, Canada.




*Part of the eastern Pacific Ocean sea floor and of the west coast of South America are depicted on the portion of the fifth edition of the* General Bathymetric Chart of the Oceans *(GEBCO), reproduced here in black and white. The sea floor in this region is about 4,500 metres deep and is moving slowly towards South America at a rate of almost 9 centimetres a year. The 7,000-metre-deep Peru-Chile Trench is formed at the margin of the continent, where the sea floor plunges down into the interior of the earth and slowly melts. GEBCO was prepared by marine scientists from many countries and was published by Canada. The work was carried out under the auspices of Unesco's Intergovernmental Oceanographic Commission (IOC) and the International Hydrographic Organization.*

Photo © the Minister of Supply and Services, Canada, 1984




lowed by a vessel. Shortcomings of this method include errors in data resulting from under-sea obstacles and variations in the speed of sound through water (caused by differing salinity, temperatures and depth).

The systematic compilation of depth charts, called the *General Bathymetric Chart of the Oceans* (GEBCO), dates from the time, early in this century, when Prince Albert I of Monaco realized that the best possible maps of any surface, undersea as well as on land, are a critical tool in good management of the resources and environment of the sea. Publishing GEBCO the first time was fairly easy: in 1903 knowledge was so scanty that the job took only seven months to complete. As the next three editions were researched and compiled, oceanographers became aware of massive relief features found on the sea floor, for example, the spine-like mid-ocean ridges of the Atlantic and the Pacific. They did not understand that geological processes gave rise to, then changed, these large-scale features.

The current (fifth) edition of GEBCO has been compiled under the aegis of the Unesco-based Intergovernmental Oceanographic Commission and of the International Hydrographic Organization, and was made possible by new research in geology and geophysics that has enabled scientists everywhere to estimate trends in the shape and materials forming the sea bed. The huge amount of depth data, collected for the most part since the 1950s, has been integrated into the fifth edition of GEBCO. This was published in 1982 by the Canadian Hydrographic Service after seven years of exhaustive compilation—compared to the seven months required for the first edition eighty-three years ago.

The latest edition of GEBCO, like its earlier versions, is both a major improvement over the previous charts and a significant contribution to scientific knowledge; it is a scientific synthesis of all oceanographic and hydrographic investigations stretching over more than a century. To a geologist, poring over GEBCO is like reading an exciting book on the history of ocean basins and continental

margins and on the geological processes that formed them.

GEBCO was drawn up by geological oceanographers from millions of depths soundings. Although this number seems large, it must be remembered that the ocean has a total area of some 360 million square kilometres. Thus the number of soundings is generally insufficient to portray accurately the bathymetry of the ocean floor by using a purely geometrical joining up of depth points. So the science of geomorphology is used to interpret scattered data, combined with some detailed studies, in order to obtain reliable bathymetric contours at the GEBCO map scale. Depth soundings near continents are usually more numerous.

The basic data for GEBCO were gathered by ships using single-beam echo-sounders. In recent years, a new sounder, using fifteen beams side by side, has come increasingly into civil use as a scientific instrument. This "swath-sounder" uses a computer to integrate soundings and produces a detailed contoured strip-chart of the deep sea floor that is a few kilometres wide.

The high quality of GEBCO's fifth edition can be judged from a detailed swath-sounding record made by the Federal Republic of Germany's research vessel *Polarstern* in the Atlantic Ocean between Europe and South America late in 1984. Only two differences were found: an undiscovered seamount off Brazil, and a correction to the measurements of a submarine canyon off southern Argentina.

At the next stage above purely navigational charts, bathymetric maps like GEBCO and its larger-scale cousins (such as the *Bathymetric Chart of the Mediterranean Sea*) are the basic portraits of the sea floor for both general and geological uses. There are also specialized charts of the sea bed produced from geological and geophysical data showing sediment and rocks, magnetic and gravity fields, sediment thickness and so on. Multi-beam echo-sounders can be turned to "look sideways" in order to produce shaded images of the sea floor; these resemble photographs.

Information for specialists can be synthesized into geological charts, as has been done in the ocean sheets of the *Geological Atlas of the World*, a twenty-two-sheet array produced by Unesco and the International Commission for the Geological Atlas of the World (also compiled by geologists from all over the world).

Since the early 1970s, more and more nations have become vitally interested in the ocean and its resources—a curiosity stimulated by the eight years of intensive negotiation to draft, by 1982, a Convention on the Law of the Sea.

Over many years, carelessness and mismanagement have led to depletion of some species of fish and other seafood in waters that had been rich and productive. The search for petroleum under the seas and its production took explorers far along the continental shelves, virtually everywhere. While the new energy sources are welcome, the ensuing pollution problems, including oil spills perilous to flora and fauna, are much less so. A variety of useful metals and other minerals are now within our reach and some nations consider many of these economically significant for the future and are planning their extraction from the sea bed. Good bathymetric charts and geological maps are essential tools for such study, exploitation and conservation of the natural resources of the ocean. ■

**DALE KRAUSE** *has been head of Unesco's Division of Marine Sciences since 1973. A specialist in marine geology and tectonics, he has led oceanographic expeditions in the Pacific and Atlantic oceans.*

**JACQUES RICHARDSON** *was head of Unesco's Science and Society Section from 1972 to 1985. He edited* Managing the Ocean: Resources, Research and Law, *a book co-published last year by Unesco and Lomond Publications, Inc., Maryland, USA.*

Photo Unesco

***Right, this example of a geological map of the sea floor is taken from sheet 21 of Unesco's* Geological Atlas of the World *which covers the Indian Ocean.***

***The centre line of the symmetrical stripes marks the axis of the mid-ocean rift where the sea floor is moving apart at a rate of about 1 to 2 centimetres a year. Molten lava wells up along this crack and becomes new sea floor as it cools. Thus the age of the sea floor increases progressively the farther it is from the ridge. The age of the sea floor is shown on the map as stripes (coloured on the original sheet) and ranges from zero, where the sea floor is currently forming, to over a hundred million years south-west of Madagascar.***

***Among other features shown on this geological map are: the location of geological faults (heavy black lines); the kinds of rock found in drill cores taken from the sea floor; contours showing the thickness of sediment that has slowly deposited on top of the cooled lava; the location of earthquakes (black dots, red on the original sheet); and the location of active volcanoes (triangles). Land appears dark grey as reproduced here.***

***This geological map of the Indian Ocean was prepared by marine geologists under the auspices of the Commission for the Geological Atlas of the World. The Atlas consists of 22 sheets—6 small-scale maps covering the oceans and 16 larger-scale maps covering the continents. The Atlas is a major scientific contribution to human knowledge because it summarizes the geology of the entire earth. It was made possible by the hard work of land and marine geologists from all over the world, co-operating within Unesco. The Atlas is published by Unesco and is available through Unesco sales agents.***

# Glossary

**Bathymetry** Measuring the depths of the sea, including the slopes descending from the continents and probing the shape of the ocean floor

**Contour** In mapping, an imaginary line joining all points having the same height or depth

**Cretaceous** A geological period extending from about 135 million years to 65 million years ago

**Geology** Study of the rocks, soils and minerals of our globe's structure and history

**Geomorphology** Study of the geological evolution of land-forms

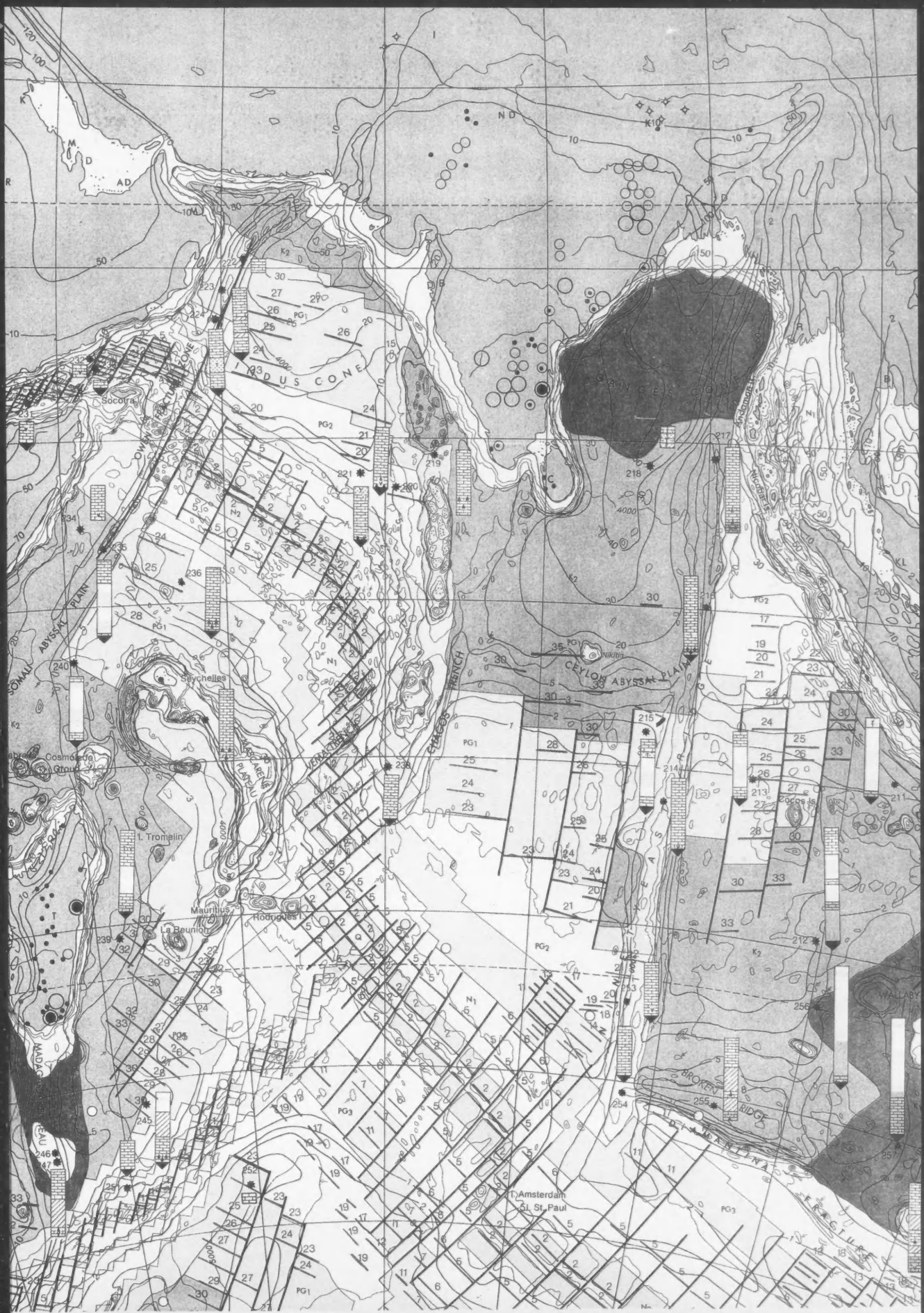
**Geophysics** Study of the forces of nature at work (heat, gravity, magnetism, radiation, weather and climate, volcanoes and earthquakes) and how these affect the structure and the evolution of the globe

**Guyot** Flat-topped submarine mountain also known as a tablemount

**Seamount** A cone-shaped submarine mountain rising from the deep sea floor

**Sonar** SOund NAvigation Ranging, the detection of submerged objects by the sensing of reflected sonic and sub-sonic waves (a sub-sonic wave is inaudible to the human ear)

**Tectonics** Geophysical processes whereby the earth's crust constantly shrinks and shifts, thus causing faults, rifts, earthquakes and volcanic eruptions


INDUS CONE
GANGES CONE
SOMALI ABYSSAL PLAIN
CEYLON ABYSSAL PLAIN
OWEN FRACTURE ZONE
CARLSBERG RIDGE
CHAGOS TRENCH
BROKEN RIDGE
NINETYEAST RIDGE
WALLABY
Socotra
Seychelles
Cosmoledo Group
I. Tromelin
Mauritius
Rodrigues I.
La Reunion
Nikitin
Cocos Is.
Andaman Is.
Nicobar Is.
I. Amsterdam
St. Paul

# *The nature and purpose of marine science*

OCEAN science is concerned with the investigation of the world ocean, its biota and its physical boundaries with the solid earth and atmosphere. It is no different from any other scientific field in its use of the scientific method, in which careful description leads to the formulation of hypotheses and their testing by experiment.

As in other earth sciences, the testing of hypotheses can only occasionally be accomplished by the conventional sort of laboratory experiment where the important variables are under the experimenter's control. More commonly a "geophysical experiment" must be undertaken, where the experiment is performed by nature and the scientist is limited to observing its various phases at different times and locations.

Scientific problems in the ocean tend to involve more than one discipline, so that their solution often calls for collaboration among scientists with different experience and skills. And because of the large dimensions of many oceanic processes and the fact that their occurrence and location are seldom coincident with the limits of national jurisdiction, ocean science depends heavily on international co-operation.

Different countries assign different degrees of importance to marine research. While the industrialized maritime countries are generally the major investors in these activities, some developing countries have also assigned high priority to ocean studies. In recent years the number of marine scientists, institutions and research vessels has increased considerably in many countries, including those of the tropical and sub-tropical zones. Nevertheless, ocean research continues to have a low priority in many States, in part because of the lack of awareness of the need for, and benefits of, such research for overall economic and cultural development.

There appear to be compelling reasons now for giving increased priority to the support of basic marine science and its application to ocean use and management. The main reason is that an ever-expanding world population is placing increasing pressure on all the resources of the planet and this growing need for food, minerals and energy cannot be fully met from the land. Thus demands on the ocean will increase as land sources are depleted and as their increased cost makes ocean exploitation economically feasible. But rational use of the ocean and its resources will depend heavily on scientific knowledge, which in many cases does not at present exist.

There is a broad spectrum of kinds of research, ranging from the most fundamental with widespread relevance but no obvious short-term application to that with immediate, specific application but with little relevance to other problems. The time-scale of pay-off varies greatly and it is usually difficult to predict just when the application of research findings will become feasible. It is important to remember that applied research draws on the reservoir of scientific knowledge, and it is often the case that problems of immediate concern cannot be solved without additional research of a very fundamental character.

For example, the growth in scientific manpower and facilities and their extensions to new locations will in the long run permit a better scientific coverage of many regions previously neglected due to their remoteness from traditional centres of scientific activity. But it would be unfortunate if this effort were to be limited to specialized measurements for fisheries, or for petroleum or mineral development on the continental shelf. Until the present gaps in our basic information on, for example, ocean circulation and major ecosystems are filled, it will be very difficult to use these resources wisely or to predict the consequences of harvesting them.

The Convention on the Law of the Sea, accepted by many countries in 1982, assigns much of the world ocean to exclusive national economic zones where coastal States have jurisdiction over the exploitation of resources. The wise use of these resources, both living and non-living, will require scientific knowledge that is often not now available. Thus the new Law of the Sea serves to increase the need of coastal States for scientific research in these offshore regions.

This is true for all coastal States, regardless of their level of development, but becomes particularly important when their coastal inhabitants depend directly on food from the sea and when alternative sources of food and other resources ashore are very limited. The need to understand oceanographic processes within a few hundred kilometres of the coast is thus widespread and provides strong justification for enhanced international co-operation in ocean research.

Perhaps the most imperative reason for such collaboration is the mismatch between the dimensions and locations of oceanic processes and phenomena and the national boundaries that are imposed on the ocean system. In some regions, for example the Gulf of Guinea or the Caribbean Sea, the ocean circulation and the distribution of fish are common to the several bordering countries and their investigation can only be effectively accomplished through regional collaboration.

Finally, it should be observed that the dimensions of some ocean phenomena vastly exceed the national domains of affected countries and it is not uncommon for local events to be driven by processes operating in distant parts of the ocean. A classic example is El Niño, a phenomenon in which the fisheries of the coastal waters of Peru and Chile may be affected by an ocean circulation pattern across the entire equatorial Pacific and by atmospheric conditions over the entire planet. This emphasizes the need for collaboration at the global level to provide the necessary insights into the atmospheric and oceanic causes of changes in both local and large-scale climate. ■

*This article is extracted from* Ocean Science for the Year 2000, *a report on an inquiry by the Scientific Committee on Oceanic Research and the Advisory Committee on Marine Resources Research for the Intergovernmental Oceanographic Commission and Unesco, published by Unesco in 1984.*

## COLOUR PAGES

***Opposite page, detail from a relief map of the ocean floor showing the submerged "spine" of the Atlantic Ocean—the mid-Atlantic Ridge.***

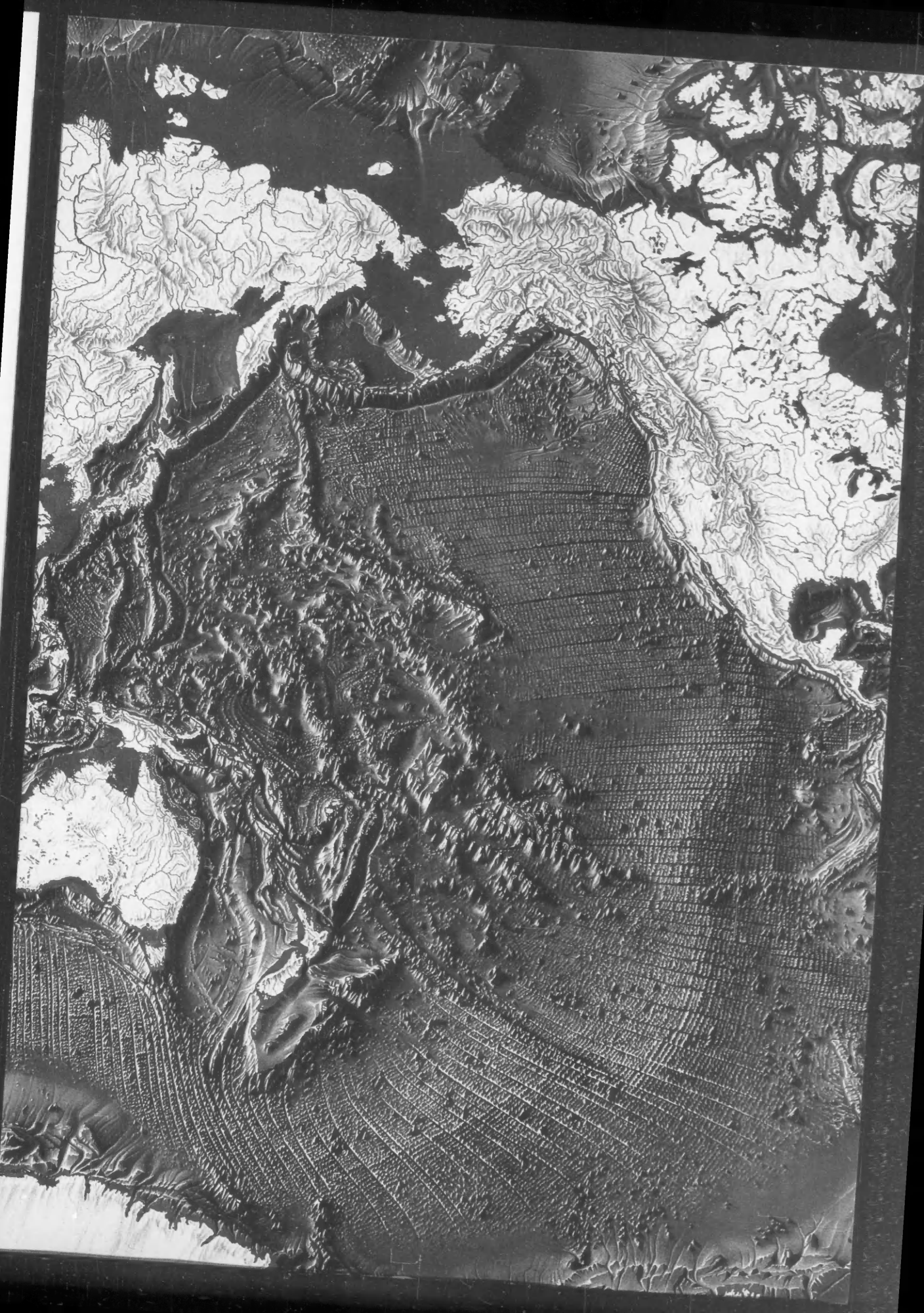
Photo © Hachette/*Guides Bleus*, Paris. Detail from *Carte du Fond des Océans*, by Tanguy de Rémur

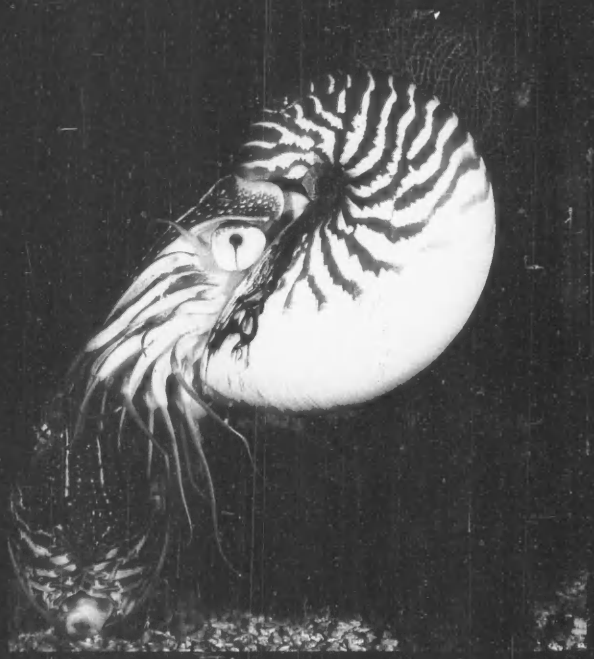
***Page 20, specimens of marine life form a pageant of astonishing variety and beauty. Clockwise from top left: (1) The Moorish idol (Zanclus cornutus) is an Indo-Pacific tropical fish that grows to be 22 cm long. (2) A nautilus. Its spiral-shaped shell contains a number of chambers. It adds a new chamber to its cell each time it outgrows an old one. (3) Delicate tracery of coloured markings dot the arms of a bevy of starfish. Most starfish have 5 arms although some have as many as 50. (4) Seafloor landscape of multicoloured corals and sponges.***

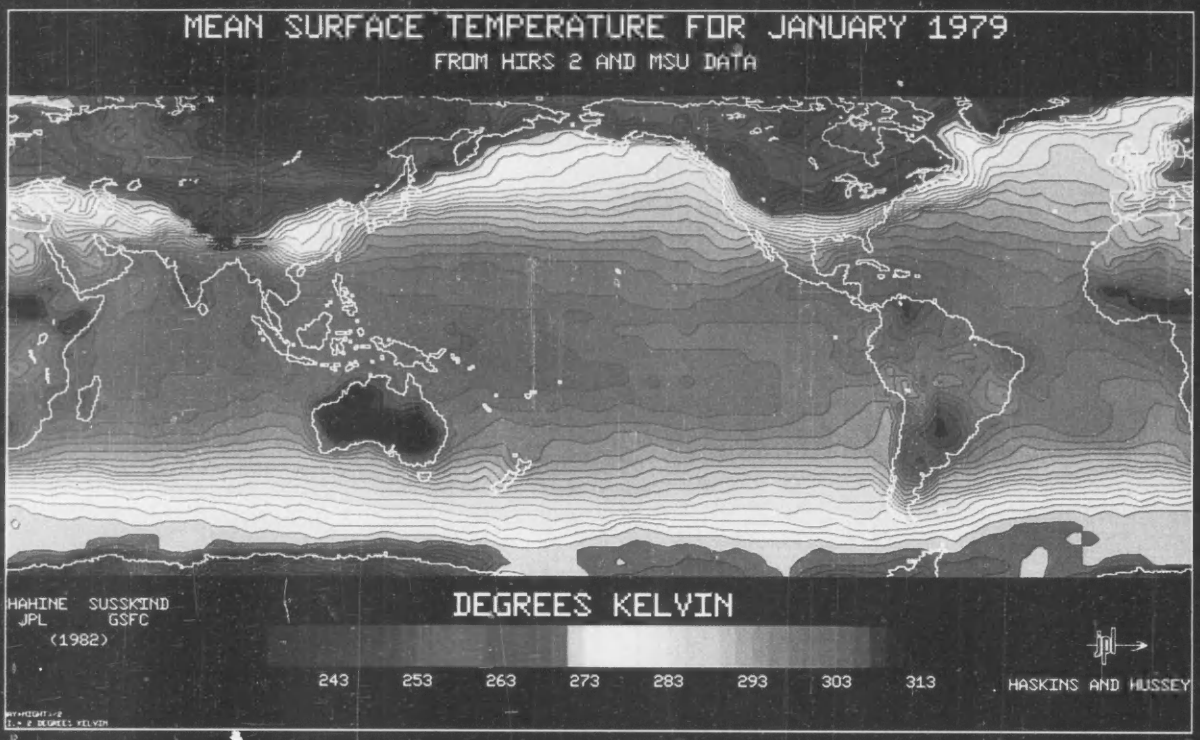
Photos 1 and 3, Myers © A.A.A., Paris
Photos 2 and 4, Sylllebranque © A.A.A., Paris

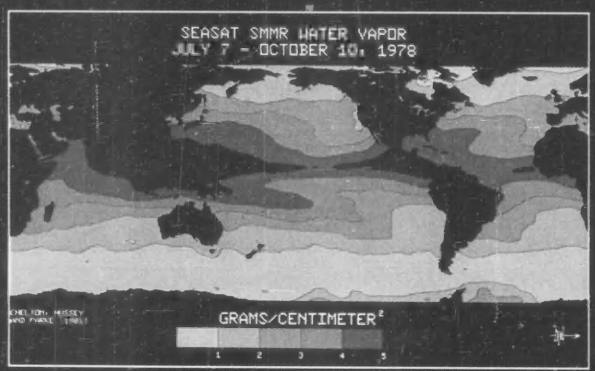
***Page 21, view of the 400-kilometre-long barrier reef, the world's second largest after the Australian Great Barrier Reef, that encircles New Caledonia in the southwest Pacific.***

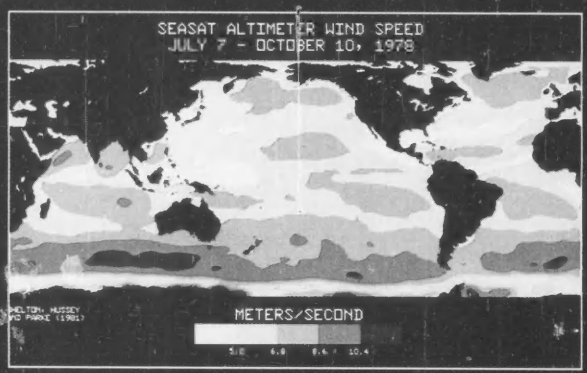
Photo Sylllebranque © A.A.A., Paris

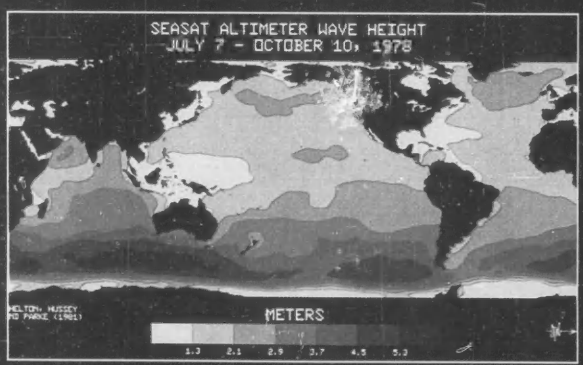





MEAN SURFACE TEMPERATURE FOR JANUARY 1979
FROM HIRS 2 AND MSU DATA
HAHINE SUSSKIND
JPL GSFC
(1982)
DEGREES KELVIN
243 253 263 273 283 293 303 313
HASKINS AND HUSSEY


SEASAT SMMR WATER VAPOR
JULY 7 - OCTOBER 10, 1978
GRAMS/CENTIMETER²
1 2 3 4 5


SEASAT ALTIMETER WIND SPEED
JULY 7 - OCTOBER 10, 1978
METERS/SECOND


SEASAT ALTIMETER WAVE HEIGHT
JULY 7 - OCTOBER 10, 1978
METERS

# *Satellites scan the ocean*

## *Modern technology in the service of oceanography*

*by D. James Baker*

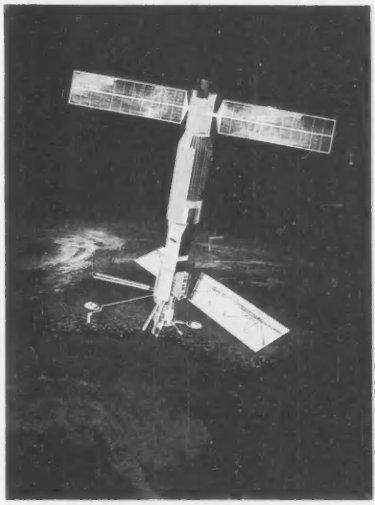


Photo © Etevé, IPS, Paris

***The SEASAT satellite which produced the global measurements of water vapour, wind speed and wave height illustrated on colour page opposite. Drawing shows SEASAT in polar orbit over Alaska.***

WHEN I entered oceanography in the early 1960s, rapid strides were being made towards describing and predicting ocean behaviour. The first expedition in which I participated spent six months in the Indian Ocean helping to measure the currents and winds in the equatorial regions there. But the technology and the research ships available to us at that time had serious limitations. The ship we used was the *Argo*, a former submarine rescue ship deeded from the United States Navy to the Scripps Institution of Oceanography and our equipment was largely devoid of electronics. Our officers used celestial navigation, dead-reckoning and local measurements. The difficulty of obtaining any kind of global view or photograph of conditions at any one time over a large area of the Indian Ocean was painfully obvious.

Today, our instruments are much more sophisticated, largely because of the revolution in micro-electronics and computers, but the limitations of measurements from ships are still with us. Measurement of the ocean from satellites promises to liberate us from many of these shipboard limitations. Navigation by satellite, a technique that uses satellites and on-board receivers and computers, is commonplace for research ships and commercial vessels. Accurate positioning is available at two hourly intervals in most regions of the world and in any weather conditions. We are also now beginning to use other satellite data to get photographs of the behaviour of the oceans—its temperature, the shape of its surface, its waves and its chemical and biological properties.

The ocean is a subject of intense interest to the applied scientist for a variety of reasons. Whereas in the past increasing energy and food requirements could be met by expansion of frontiers, use of chemicals for fertilizers and pesticides, and by using available reserves of gas and oil, we are today being confronted by the finite dimensions of the world. We are at the point where we affect both regional and global climate. We are a factor in the ▶

**COLOUR PAGE OPPOSITE**

***Top photo shows the first global map ever put together of the surface temperature of the earth. The temperatures shown on the map correspond to those of January 1979. The colour scale shows temperature expressed in degrees Kelvin (a temperature expressed in degrees Centigrade is equal to the temperature in Kelvins less 273.15. For example, the light yellow band at centre of the colour scale shown beneath the map is approximately equal to zero degrees Centigrade). Since the cold polar regions cover only a small part of the globe relative to the warm equatorial regions, the mean surface temperature of the earth is clearly dominated by the temperatures in the tropics. The map shows several cold regions, such as Siberia and northern Canada, and a hot Australian continent during the southern hemisphere's summer. The effect of the Gulf Stream is clearly seen off the eastern coast of the United States (the temperatures there are cooler than at comparable latitudes on the eastern side of the Atlantic Ocean). Maps such as these are used to establish the basic parameters of global air/sea interaction for understanding climate.***

Photo courtesy of M. Chachine, NASA/Jet Propulsion Laboratory, California Institute of Technology, Pasadena

***Lower photos illustrate global measurements of water vapour, wind speed and wave height made by the SEASAT satellite between 7 July and 10 October 1978. The water vapour in the atmosphere affects the earth's surface radiation balance and, together with wind speed, is important for studies of climate. As expected, most water vapour is found in the tropics, where evaporation is high. The wind speed is measured by inference from the shape of the waves, which in turn is measured by altimeter. The modern altimeter is a radar device that sends down a pulse from the satellite which is reflected back to the satellite. The time it takes to go from satellite to ocean and back again tells us how far the sea surface is from the satellite and hence the shape of the surface under the satellite track. From the surface shape the waves and general topography of the surface can be determined. The wind speed and wave height show the strongest intensity in the southern oceans, particularly south of Australia. These measurements illustrate the importance of satellite measurements for such data, since this is a region generally devoid of ships that can take direct measurements. For the first time we now have measurements of wind and waves in this region.***

***The altimeter can measure more than waves since variations in the sea's surface height are also caused by ocean currents. For example, the Gulf Stream has variations of height across its width of about one metre. Such variations can be measured by the satellite altimeter and promise to provide global pictures of ocean circulation as well as waves. This is one of the most exciting possibilities of the new satellite data.***

Photos courtesy of D. Chelton NASA/Jet Propulsion Laboratory, Pasadena

▶ global cycles of carbon, nitrogen, phosphorus and sulphur because we produce significant amounts of these chemicals and dump them into the air and the sea. It is essential that we understand how the overall ocean-atmosphere system works if we are to live successfully with global change. We have to understand the cycling of energy, waste and essential chemicals through the atmosphere, land and oceans.

The oceans regulate the climate and make it more predictable. The slow variations of ocean currents which affect the transfer of heat to the atmosphere could, in the view of many experts, provide a mechanism for predicting the climatic changes in the atmosphere. But in order to understand these variations of ocean currents we need to understand the general circulation of the ocean, how the currents are driven and how and why they change. Another largely unknown factor in the climatic system involves the role of sea-snow and sea-ice. Both of these are quantities that can be measured and monitored by satellite.

The distribution and cycling of nutrients is also important to the "habitability" of our planet. The nutrients are related to the biological productivity cycle through the atmosphere, rivers, coastal zones and the deep ocean. The continental shelf is a critical area. Most of the world's fisheries occur here, much of the world's petroleum production may be in these areas in the future and it is here that most of man's pollution enters the ocean. The shelf is a direct source of food for humanity and the pressures on this food supply are increasing rapidly. We must know what is happening here and we must be able to understand the mechanisms that control the transport of these nutrients from terrestrial sources to oceanic sinks. To do this we must be able to understand the interactions between physical and biological processes in the oceans. Large-scale satellite views of nutrients in the ocean are necessary for this understanding.

Changes in the amount and timing of global rainfall are critical for farmers. The green revolution has shown dramatically how genetic engineering can provide farmers with exactly the right kind of crops for a maximum of productivity if the water resources are known. Thus rainfall is critical, but we must know it globally. The problem is not yet solved; in fact, the natural rainfall patterns over the globe are only marginally predictable by the use of climate models now available. Global rainfall is another parameter that we can measure by satellite.

For the oceanographer, ships are essential. There is no other way to get samples of water, chemicals or biological organisms from the sea. But ships alone cannot give us an overall view of the ocean. A typical research ship travels at about ten knots; at that speed it takes about ten days to make a single crossing of the North Atlantic. It can therefore take months to complete a careful survey of any large region, and in that time the state of the ocean can change drastically.

From ships and from the relatively few buoys that are moored in the ocean for weather measurements and for research purposes, we get an average view of the ocean's properties (for example its temperature and salinity) and of near-surface weather. This average view is important, but we have to recognize that the ocean is continually changing. It does not change as fast as the atmosphere, but it does behave in a similar way. The atmosphere changes its weather in a few days and its climate varies from year to year. The ocean's "weather", that is, the currents and temperatures, changes over periods of a few weeks instead of a few days. The ocean's "climate" also changes from year to year.

But how do we get an overall view of the ocean? Our instruments have to be placed in a position away from the earth in order to see it all at once. Satellites are the only way. Typically satellites receive their power from the sun, and they are classified as either passive or active. The passive satellites receive the radiation that comes from the earth and attempt to interpret it; the active satellites illuminate the sea with specified radiation and observe the reflected pulses. We now have satellites that can measure the shape of the ocean's surface, the surface temperature of the ocean, the wind speed near the surface, the extent of the polar ice, the surface chlorophyll and a variety of properties in the atmosphere.

From these instruments we get a global view—either an image of almost half the earth at a time from a satellite in geosta-

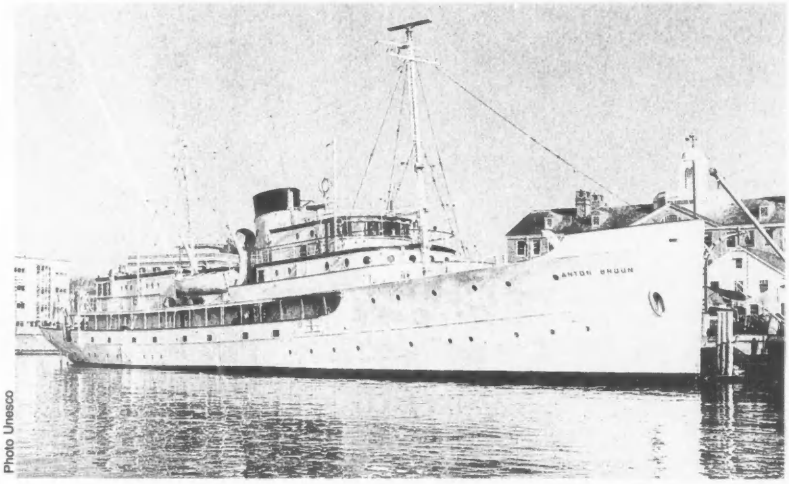



Photo Unesco

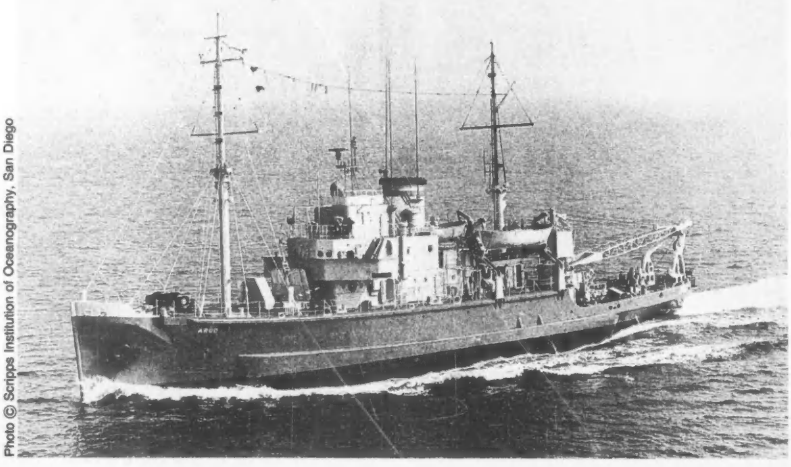


Photo © Scripps Institution of Oceanography, San Diego

***Above, the US research ship* Anton Bruun, *which took part in the International Indian Ocean Expedition. Before being refitted for ocean biology research and renamed in honour of the famous Danish oceanographer, it was the US presidential yacht* Williamsburg.**

***Left, the* Argo, *the research vessel of the Scripps Institution of Oceanography, San Diego, California.***

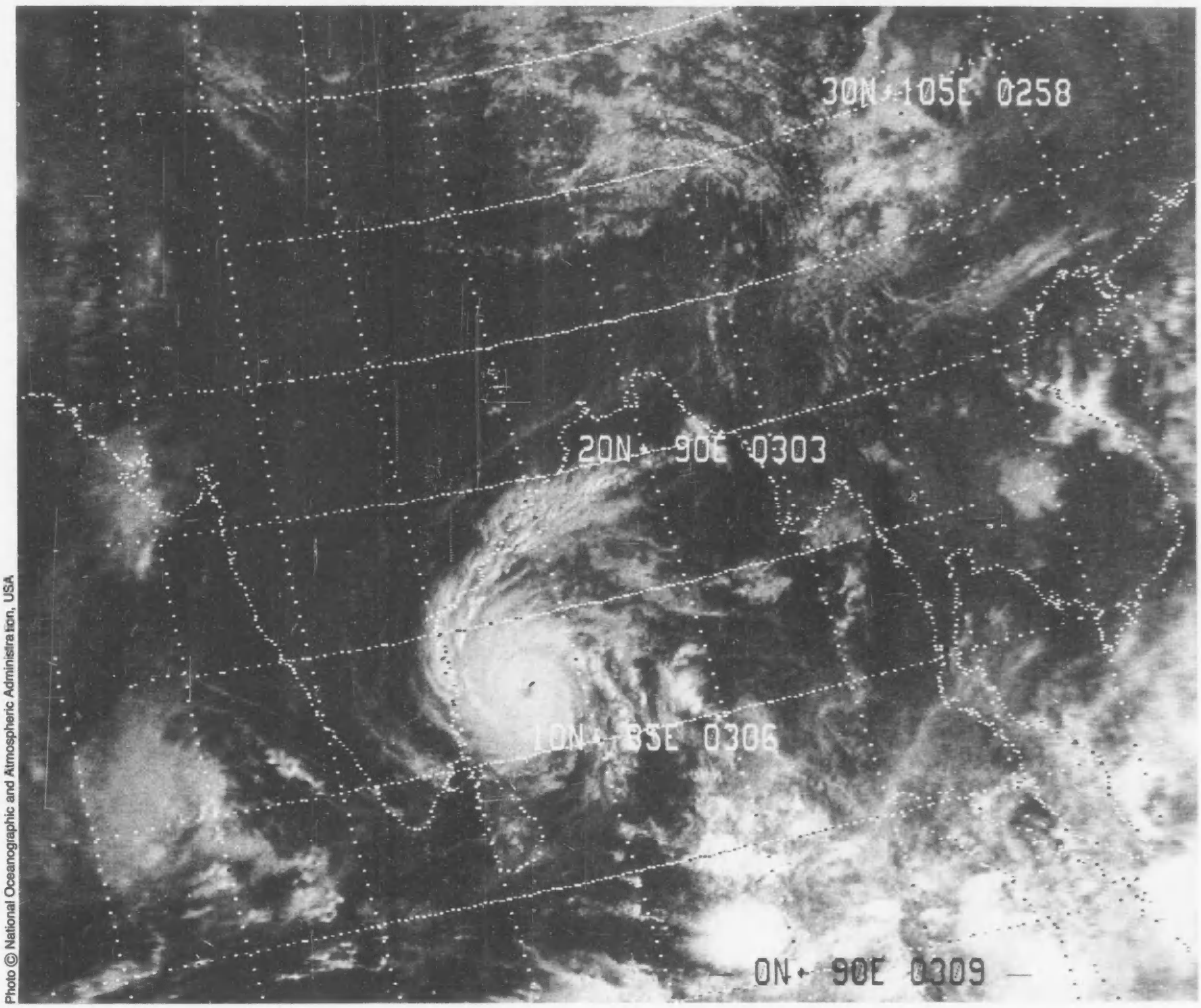



Photo © National Oceanographic and Atmospheric Administration, USA

***Satellite image of a cyclone over the Indian Ocean***

tionary orbit, or from a series of tracks of "low earth orbiter satellites" which travel closer to the earth and repeat their orbits about every ninety minutes. Thus we have at our disposal a new and remarkable series of pictures of the ocean and the land, and this new imagery has dramatically changed the way in which we view the ocean, allowing us to plan for new research programmes. We now see the possibility of describing and understanding some of the important cycles of climate, of nutrients and of other environmental factors that affect global habitability.

Enormous quantities of data have been collected since the early 1960s, when satellites first came into use, but it is only in recent years that satellite pictures that can be used for real scientific understanding of the ocean have become available. The four photographs on page 22 demonstrate the power of these new techniques.

Encouraged by this technological advance, a number of scientists have proposed the establishment of an international *Global Habitability Programme* aimed at improving our understanding of the climate and the global cycles. The central elements of the programme would be satellite measurements by many nations and shipboard and land-based measurement and modelling of the ocean, the earth and the biosphere. Using satellites, ships and computers, environmental scientists have the technology to carry out the required research. In addition, their theoretical tools have advanced to the point where the integrated study of the global system is becoming feasible. With scientists working together internationally it is possible that rational management of the earth and its resources may be achieved. ■

**D. JAMES BAKER,** *of the USA, is Dean of the College of Ocean and Fishery Sciences and professor of Oceanography at the University of Washington Seattle. He is a member of the Board on Ocean Science and Policy and the Climate Research Committee of the US National Academy of Sciences as well as of the Earth and Space Sciences Advisory Committee of the National Aeronautics and Space Administration. He is the author of many articles on the general circulation of the ocean, the role of the ocean in climate variation, and ocean technology. This article is extracted from a longer study first published in the Unesco science magazine* Impact of Science on Society.

# Twenty-five years of research

## The Intergovernmental Oceanographic Commission

TWENTY-FIVE years ago, international co-operation in marine science was in its infancy. Although serious scientific investigation of the deep oceans had begun almost a century earlier, when, on a cold grey December day in 1872, the British corvette *HMS Challenger* set out on an historic three-and-a-half-year round-the-world oceanographic exploration cruise, international oceanographic research as we know it today did not commence until after the Second World War.

The *Challenger* brought back valuable information on ocean temperatures, ocean currents and the depths and main contours of the great ocean basins, and other governments were quick to mount similar expeditions.

These, however, were individual, unco-ordinated efforts and, rather surprisingly, it was not until the 1950s that marine scientists and governments came to realize that, if ocean properties were to be adequately measured, the measurements would have to be made in many places simultaneously.

The success of the first truly international co-operative venture—the investigation of the Atlantic Polar Front in 1958, within the framework of the International Geophysical Year—demonstrated what could be achieved through international co-operation. It also demonstrated the need for some form of international organization to which governments would be prepared to give their wholehearted backing.

It was in this context that an Intergovernmental Conference on Oceanographic Research, held in Copenhagen in 1960, recommended the establishment, within Unesco, of the Intergovernmental Oceanographic Commission, more familiarly known as the IOC, which it charged with the task of promoting "scientific investigation with a view to learning more about the nature and resources of the oceans through the concerted actions of its members".

During the twenty-five years that have elapsed since that momentous meeting the IOC has grown both in numbers and in stature. The forty original Member States have swelled to 113 and the Commission itself has gained recognition as the world leader in international oceanographical research.

A major turning point in the life of the IOC came in 1969 with the establishment of the Key Long-Term Expanded Programme of

***The route taken by HMS Challenger during her historic oceanographic research cruise, 1872 to 1876.***

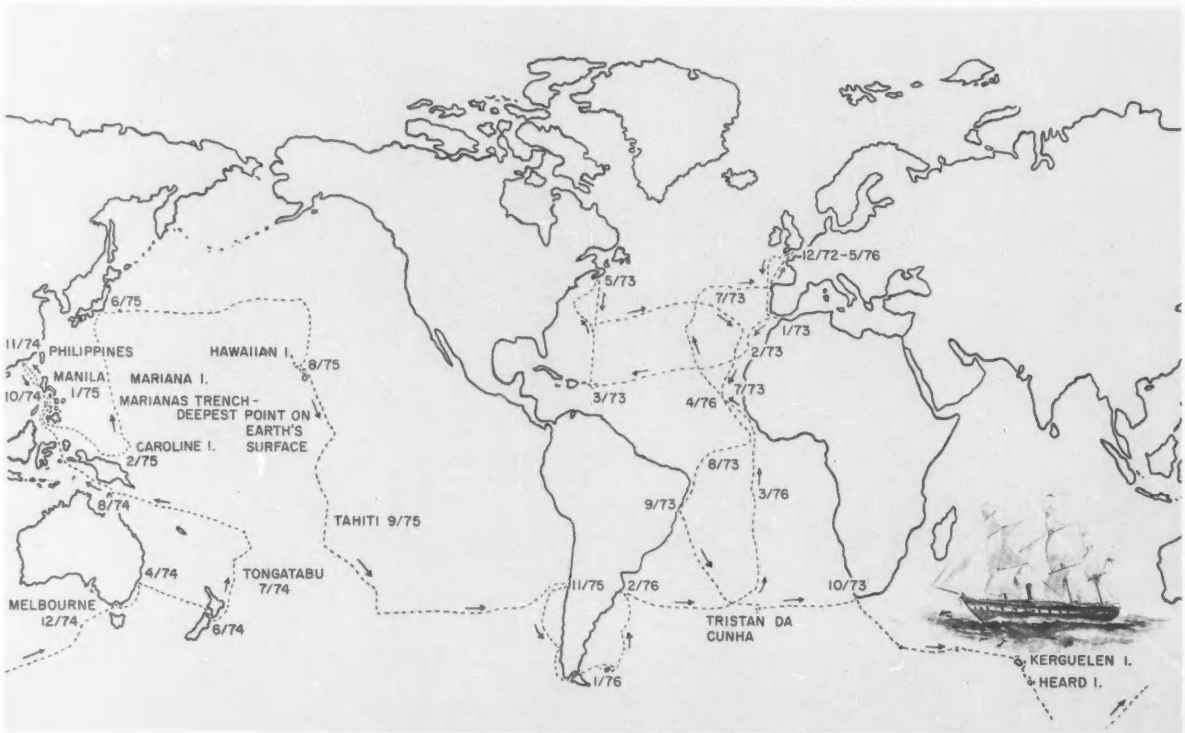



Photo taken from *Exploring the Secrets of the Sea*
© William J. Cromie

Oceanic Exploration and Research (LEPOR) which was to determine the main thrust of the Commission's activities for years to come.

An event of equal importance for the IOC, and indeed for the world, was the signing in 1982 of the United Nations Convention on the Law of the Sea, which is expected to extend the scope of the IOC's responsibilities very considerably.

Throughout its twenty-five years of existence the IOC has been taking innovative initiatives that have helped to push back the boundaries of oceanographic knowledge. These include: a new approach to the relationship between the marine environment and the living resources of the sea; the preparation of specialized maps of the ocean, in particular bathymetric (ocean depth) charts, maps of the sea bed and of its geological and geophysical characteristics; the setting up of two international experiments on the relationship between the ocean and the atmosphere; the global investigation of marine pollution; the establishment of a system of collection, classification, exchange and analysis of ocean data; and, the elaboration of a comprehensive plan for a Major Assistance Programme to Enhance the Marine Science Capabilities of Developing Countries.

During the past quarter of a century the objectives of the IOC have remained fundamentally the same, although they have been broadened and clarified. The Commission's aims today could be summed up as being:

- to identify problems the solutions to which require international co-operation in ocean research;
- to develop scientific investigation of the oceans and the related services such as international oceanographic data exchange and ocean observing systems;
- to strengthen the marine scientific and technical capabilities of its Member States through training, education and mutual assistance.

The silver jubilee of the IOC, which was celebrated during the thirteenth session of the Assembly, held in Paris from 12 to 28 March 1985, provided a special opportunity for a critical review of the Commission's work and the formulation of guidelines for future activities.

Photo Unesco

***A researcher prepares to lower a net designed for taking plankton samples.***

*The governing body of the IOC is its Assembly which meets once every two years. An Executive Council consisting of thirty-three Member States exercises overall supervision of the implementation of the Commission's activities. The day-to-day running of the IOC is the responsibility of its chief executive officer, the Secretary of the Commission. Unesco provides most of the staff and Secretariat services and close co-operation is maintained with the Division of Marine Sciences of Unesco on projects of mutual interest. The Commission also functions as a joint specialized mechanism for discharging certain of the responsibilities, in marine scientific and technical affairs, of the five UN Organizations—UN, Unesco, FAO, WMO and IMO—members of the Inter-Secretariat Committee on Scientific Programmes Relating to Oceanography.*

# *The challenge of the new ocean regime*

IN considering the consequences of the signature, by over 150 nations, of the United Nations Convention on the Law of the Sea, the words of the Portuguese poet who said that "today is the first day of the rest of your life" come to my mind. Indeed, this historic event marks the beginning of a new relationship between mankind and the oceans. It represents to some extent the culmination of a long process of universal negotiation among States. It is also the beginning of a phase of international co-operation aimed at the achievement of the objectives of the Convention, as well as the dreams and aspirations behind its provisions.

The new ocean regime is a development with far-reaching consequences for the conduct of ocean affairs at the national and international levels. It is also a symbolic event in that it reflects the important changes that have been shaping the world community since the Second World War (characterized mainly by the process of decolonization and national self-determination) as well as by the drive for a more just and equitable economic order built on a foundation of peaceful and friendly relations between countries regardless of their political and economic systems.

Among the many features of the new ocean charter that constitute innovations with respect to the 1958 Convention on the Law of the Sea, mention should be made of the regime for marine scientific research and the transfer of marine technology. This innovation is derived from the growing perception by States of the value of science and technology, first to economic and social development and secondly as sources of power and an element of the independence of States in the modern world. Science is a fundamental component of a technological civilization. Scientific activities generate the information required for many kinds of economic activity. Without scientific data, modern States, government administrations and industrial management could not perform their functions effectively or achieve their goals.

The Convention includes a comprehensive regime for the conduct of international marine scientific research and the transfer of knowledge and technology. Some principles and rules establish the duty of States to co-operate directly with each other or through the appropriate international, regional or sub-regional organizations.

The rights accorded to coastal States—and the corresponding duties of States engaged in research—for granting or refusing their consent to research to be conducted in their Exclusive Economic Zones create favourable conditions for the participation of local scientists in research activities, training, access to required knowledge, and so on. It should be noted in this context that, besides references in the Convention to "regional centres", to be established or reinforced for the promotion of marine scientific research and technology and related training and transfer of knowledge, mention is also made of national centres to be created at the local level for the same purpose. The functions assigned to this type of institution—and the need for further elaboration of the concept of regional centres—reflect the concern for participation by, and the aspiration for real partnership among, developing countries in scientific and technological international marine programmes and activities in the future.

Pending the ratification and entry into force of the Convention, and to facilitate the progressive implementation of the new regime by States, a major requirement is the improvement or the establishment of the necessary institutional arrangements. During the Conference on the Law of the Sea, a detailed discussion on institutional aspects was deliberately left aside and was only dealt with in general terms in connexion with specific articles. Neither was there any mention by name of the appropriate intergovernmental organizations, except in a few cases, so as to avoid extra difficulties resulting from the definition of competences in various aspects of oceanic affairs within the United Nations system.

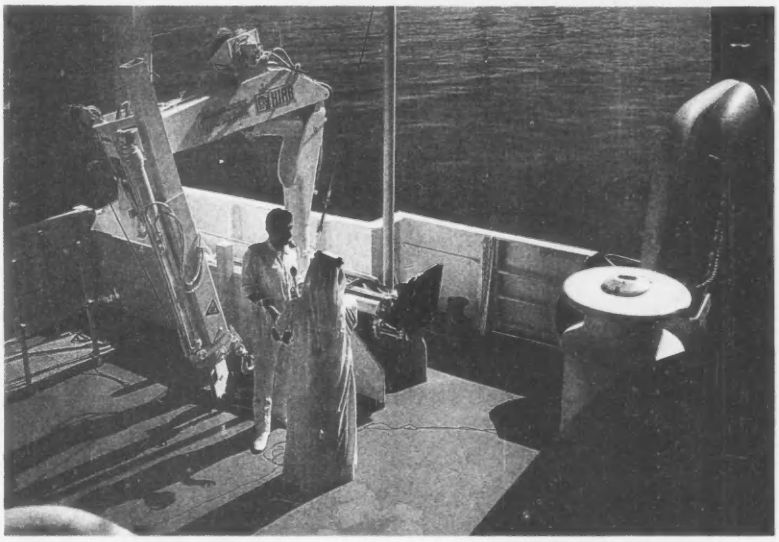
Steps have already been taken, or are under way, by a number of organizations to adapt themselves to the new demands and to prepare themselves to be able to fulfil the functions assigned to "competent international organizations" in the Convention.

Following this trend, Unesco, through

Photo Unesco

***The headquarters of IOCARIBE, the Caribbean Region branch of the intergovernmental Oceanographic Commission, in Cartagena, Colombia. It is located in the house of the Marquis of Valdehoyos, a wealthy merchant of the 18th century. Recently restored, it is one of the many fine examples of colonial architecture in the old town of Cartagena.***

*by Mário Ruivo*



Photos © Selim Morcos/Unesco

***Built from a design and study carried out under Unesco supervision, the research vessel* Mukhtabar Al-Bihar *was first commissioned in Doha, Qatar, on 9 November 1982 (above). The same design and study were used to build a sister ship for Algeria,* Benyahia *(top) which recently became active in the Mediterranean.***

the Intergovernmental Oceanographic Commission (IOC), initiated a study of the implications of the Convention in which its articles were taken as indicators of problems requiring solution through international co-operation in the fields of ocean science and services and related training and education. The aim is to strengthen the Commission's programmes and undertake the structural adjustments needed, including, eventually, improvements in the statutes of the Commission.

As an immediate step the IOC has established a new category of regional subsidiary bodies—the regional Sub-commissions—the first of which has just been created for the Caribbean and adjacent regions (IOCARIBE) as a successor to an association of the same name. It is expected that such sub-commissions will progressively replace the existing IOC Regional Programme Groups responsible for the promotion and co-ordination of marine scientific research and related activities, including the building up of regional centres and the establishment of co-operative networks.

Institutional adjustments can also be observed at the national level. In fact, traditional administrations, established usually on a strictly sectoral basis (for example, fisheries, the merchant navy) are confronted with difficulties in coping with the new problems resulting from the multiple use of the oceans and their interactions. To deal with these difficulties, two trends can be identified: one is towards the establishment of a sectoral administration dealing with ocean affairs as a whole (the establishment of Ministries of the Sea, in certain countries, falls into this category); the other is based on the full use of the existing sectoral administrations operating under a high-level national body having the power to formulate national policy in ocean affairs and to co-ordinate its implementation (this is the case, for example, of the Department for Ocean Development established in India).

In the more specialized field of marine scientific research a general trend, which has been encouraged by the IOC, is the establishment or the strengthening of marine science co-ordinating bodies, namely National Oceanographic Commissions, formed by representatives of departments of State, universities, and other institutions deeply involved in marine scientific research and applications. Such bodies are intended to mobilize the available relevant national resources and to act as focal points for international co-operation, including liaison with the IOC.

The pre-eminence given in Unesco's second Medium-Term Plan (1984 to 1989) to the activities of the Organization and, in particular, of the IOC and Unesco's Division of Marine Sciences with respect to the oceans and their resources, and the efforts to strengthen the Commission as a major instrument for the realization of the programme—especially in connexion with the Comprehensive Plan for a Major Assistance Programme to Enhance the Marine Science Capabilities of Developing Countries—should be regarded in the context of the broad institutional process under way.

It is therefore essential that non-Governmental scientific institutions concerned, such as the Scientific Committee on Oceanic Research (SCOR), also undertake a parallel effort of adjustment to the new conditions in order to become, as far as possible, universal and to reflect the views and aspirations of the world scientific community. For historical reasons, many such organizations still consist predominantly of representatives or scientists of developed countries. In fact, scientists too must learn to adapt to the new rules of the ocean game. The new ocean regime offers the potential for expansion of scientific research in the ocean through the active participation of scientists and institutions of all countries, both developing and developed, in a spirit of equal partnership. ■

**MARIO RUIVO** *is Secretary of the Unesco-based Intergovernmental Oceanographic Commission. A marine scientist specializing in the management of living resources, he was formerly director of FAO's Division of Fisheries and headed the Portuguese Delegation to the United Nations Conference on the Law of the Sea. This article is based on a longer study first published in the Unesco science magazine* Impact of Science on Society.

# Highlights of the Convention on the Law of the Sea

**Adopted on 30 April 1982 by the United Nations Conference on the Law of the Sea (by 130 votes to 4, with 17 abstentions) after more than eight years of preparatory work, the *Convention on the Law of the Sea* lays down rules for all parts and virtually all uses of the oceans. While a large part of the Convention deals with the international areas of the sea, there are important provisions recognizing the jurisdiction of States in a number of areas. The Convention will come into force when it has been ratified by sixty States, but a number of States have already altered their own national legislations to bring them into line with its provisions. Below, some of the key features of the Convention.**

• Coastal States would exercise sovereignty over their territorial sea of up to twelve miles in breadth, but foreign vessels would be allowed "innocent passage" through these waters for purposes of peaceful navigation.

• Ships and aircraft of all countries would be allowed "transit passage" through straits used for international navigation, as long as they proceeded without delay and without threatening the bordering States. States alongside the straits would be able to regulate navigation and other aspects of passage.

• Archipelagic States, made up of a group or groups of closely related islands and interconnecting waters, would have sovereignty over a sea area enclosed by straight lines drawn between the outermost points of the islands. They would have sovereignty over these archipelagic waters, while ships of all other States would enjoy the right of passage through sea lanes designated by the archipelagic State.

• Coastal States would have sovereign rights in a 200-mile exclusive economic zone with respect to natural resources and certain economic activities, and would also have certain types of jurisdiction over scientific research and environmental preservation. All other States would have freedom of navigation and overflight in the zone, as well as freedom to lay submarine cables and pipelines. Land-locked States and "States with special geographical characteristics" would have the right to participate in exploiting part of the zone's fisheries when the coastal State could not harvest them all itself. Delimitation of overlapping economic zones would be "effected by agreement on the basis of international law...in order to achieve an equitable solution". Highly migratory species of fish and marine mammals would be afforded special protection.

• Coastal States would have sovereign rights over the continental shelf (the national area of the sea bed) for the purpose of exploring and exploiting it without affecting the legal status of the water or the air space above. The shelf would extend at least to 200 miles from shore, and out to 350 miles or even beyond under specified circumstances. Coastal States would share with the international community part of the revenue they derive from exploiting oil and other resources from any part of their shelf beyond 200 miles. Delimitation of overlapping shelves would be on the same basis as for the exclusive economic zone. A Commission on the Limits of the Continental Shelf would make recommendations to States on the shelf's outer boundaries.

***The scene at United Nations headquarters in the afternoon of Friday 30 April 1982, when the Convention on the Law of the Sea was adopted by 130 votes to 4, with 17 abstentions.***

Photo Milton Grant, United Nations

• All States would enjoy the traditional freedoms of navigation, overflight, scientific research and fishing on the high seas. They would be obliged to adopt, or co-operate with other States in adopting, measures to manage and conserve living resources.

• The territorial sea, exclusive economic zone and continental shelf of islands would be determined in accordance with rules applicable to land territory, but rocks which could not sustain human habitation or economic life would have no economic zone or continental shelf.

• States bordering enclosed or semi-enclosed seas would be expected to co-operate on management of living resources and on environmental and research policies and activities. Land-locked States would have the right of access to and from the sea, and would enjoy freedom of transit through the territory of transit States by all means of transport.

• States would be bound to use "the best practical means at their disposal" to prevent and control marine pollution from any

source. The text defines which categories of States (coastal States, port States and flag States) would be responsible for preventing pollution and punishing polluters, particularly when pollution originated on board vessels, and what kinds of enforcement action were allowable. States would be liable for damage caused by violation of their international obligations to combat marine pollution. They would be bound to co-operate globally and regionally in formulating rules and standards of environmental protection, and would commit themselves to promote technical assistance to developing countries in this area.

• All marine scientific research in the exclusive economic zone and on the continental shelf would be subject to the consent of the coastal State, but those States would be obliged to grant consent to foreign States when the research was to be conducted for peaceful purposes and fulfilled other criteria laid down in the Convention. A coastal State could deny permission for such research or insist on its cessation, but only under circumstances defined in the Convention; in the event of a dispute, the researching State could require the coastal State to submit to international conciliation on the ground that it was not acting in a manner compatible with the Convention.

• States would be bound to promote the development and transfer of marine technology "on fair and reasonable terms and conditions". This would be done with proper regard for all legitimate interests, including the rights and duties of holders, suppliers and recipients of technology.

• States would be obliged to settle by peaceful means their disputes over the interpretation or application of the Convention. When they could not agree on the means of settlement, they would have to submit most types of disputes to a compulsory procedure entailing decisions binding on all parties. They would have four options: an International Tribunal for the Law of the Sea, to be established under the Convention, the existing International Court of Justice, arbitration and special arbitration procedures. Certain types of dispute would have to be submitted to conciliation, a procedure whose outcome is not binding on the parties.

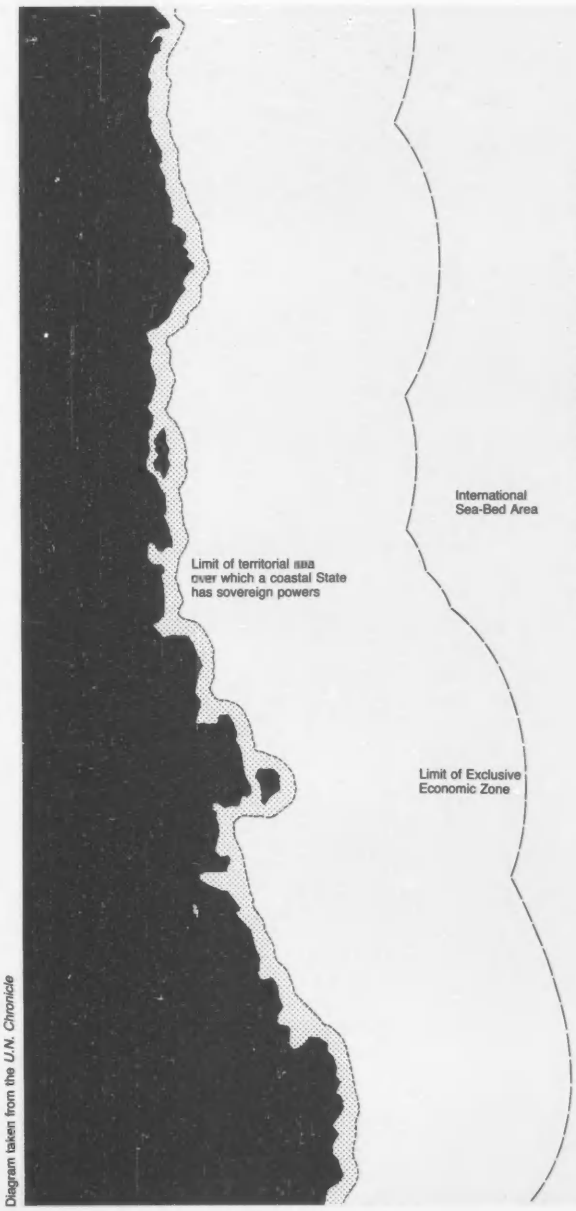



Diagram taken from the *U.N. Chronicle*

## The International Sea-Bed Area

The longest part of the Convention concerns the future regime for exploring and exploiting the bottom of the deep ocean in areas beyond the continental shelf of any State.

Of main economic interest in this area at present are polymetallic nodules lying on or just below the sea-bed at great depths, composed of manganese, copper, cobalt and nickel, although the Convention extends to all resources of the area, including any which may be discovered or which may become economically exploitable in the future.

The Convention would establish a "parallel" system for exploring and exploiting the deep sea-bed. Under this system, all activities in the area would be under the control of the International Sea-Bed Authority, which would be authorized to conduct its own mining operations through an organ called Enterprise. At the same time, the Authority would contract with private and State ventures to give them mining rights in the area so that they could operate in parallel with the Authority. The resources of the area would be managed as a "common heritage of mankind".

***Of all the minerals known to exist in and under the seas the most valuable at the moment is oil. About one fifth of total production comes from the continental shelf within 200 miles of the coast of about 75 countries and under relatively shallow water. Many such areas have not yet been tapped and vast reserves are suspected under much deeper water.***

***Nodules rich in nickel, manganese, copper and cobalt are the most valuable resource now known in the International Sea-Bed Area.***

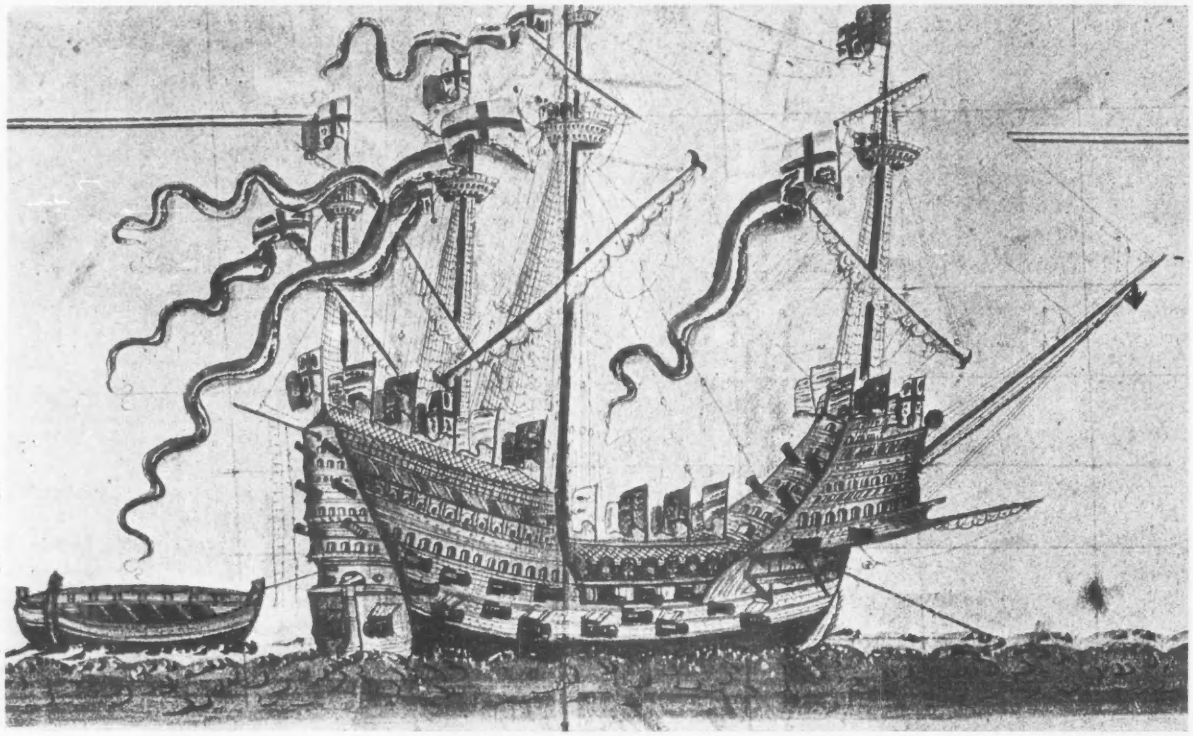


Photo © Magdalene College, Cambridge, UK

Photo You. Vladimirov © APN, Moscow

# *Living treasures of the deep*

*by Vitali Voïtov*

## *Marine flora and fauna can provide food, medicines and information about the origins of life*

***Above, watercolour dating from around 1546 shows the 700-ton* Mary Rose, *which sank off the coast of southern England in 1545. The 40-metre vessel, Henry VIII's favourite warship, was discovered by marine archaeologists in 1967 and raised from the sea-bed on 11 October 1982 after 15 years continuous work on what has been described as "the world's most ambitious underwater archaeological operation."***

BURIED in the silt of Vigo Bay, off the Atlantic coast of Spain, lie a dozen or more Spanish galleons whose rotting timbers spill out gold, the spoils of the conquistadores destined to fill the coffers of the King of Spain. Gold and silver ingots to a value of some three hundred million dollars rest on the ocean floor off the northeast coast of Brazil. Untold treasures lie concealed beneath the coastal waters of India, Sri Lanka and that former hunting-ground of pirates, the Caribbean Sea.

No one can estimate the total value of this sunken treasure, nor of the pearls that for centuries men have dived to recover from the waters of the Gulf to embellish the robes of kings and courtiers.

Yet these sunken, gleaming bars of gold and silver, so many monuments to human greed masquerading under a cloak of romantic myth and adventure, pale to insignificance when compared with the fabulous living treasure that the ocean has to offer. For the sea, in which life first evolved, contains all the major animal groupings, from simple protozoa to highly complex mammals.

Of all the living resources of the ocean, the one that has been exploited the longest by man is its renewable treasure of fish and other edible forms of marine life. Today the total world catch of fish amounts to some seventy million tonnes a year and provides around 24 per cent of the animal protein necessary for a balanced diet (see box page 34). Until comparatively recent times the supply seemed to be virtually inexhaustible, but with improvement in fishing techniques and increasing pressure on food supplies some species of fish have been over-exploited to the point of virtual extinction. If we are to preserve this living treasure there must be planned exploitation of the bounty of the ocean.

The exploitation of marine organisms for their medical, curative properties also has a long history. Records show that the

CONTINUED PAGE 36

***The 6,300-ton Soviet research ship* Academician Mstislav Keldysh.** ***Named after a former president of the USSR Academy of Sciences, it has a top speed of 16 knots and an operating range of 20,000 nautical miles.***

***The Soviet research mini-submarine* Pisces VII *which, with its sister sub* Pisces XI, *played an important role in extensive Soviet oceanographic expeditions in the Pacific, Atlantic and Indian Oceans from 1982 to 1985.***

Photo © APN, Moscow

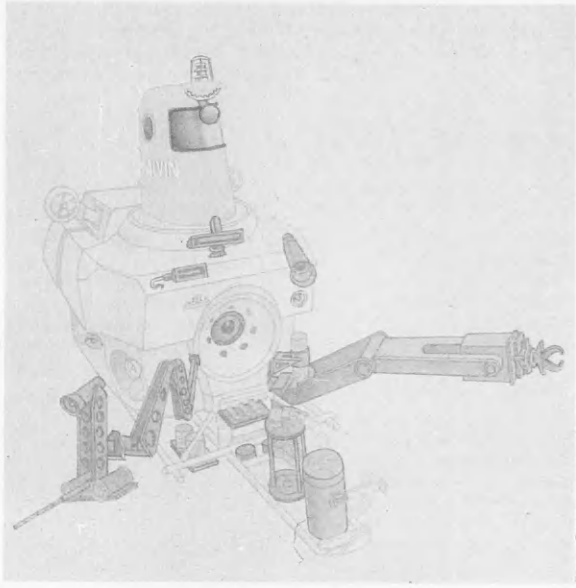
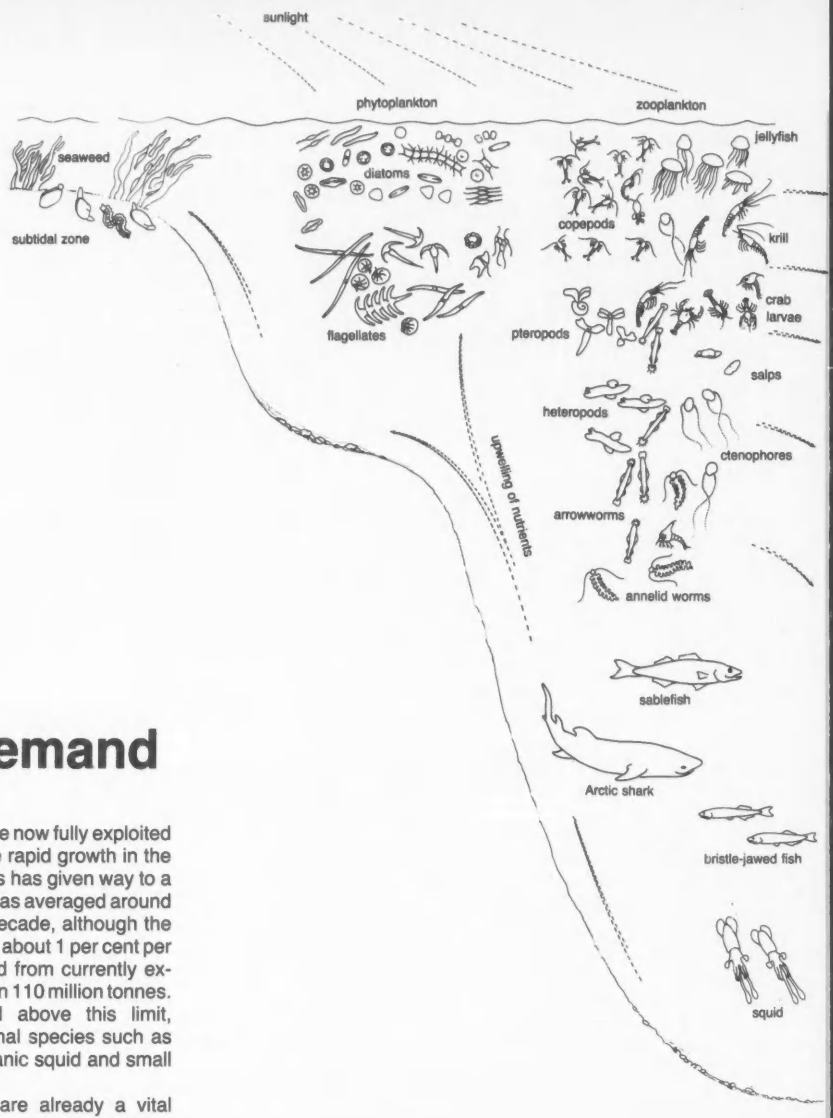



Photo © *Discover*, New York

***The two-man research mini-submarine* Alvin *in which US researchers first investigated hydrothermal vent-hole communities living on the ocean floor near the Galapagos Islands. At depths of around 2,700 metres, where sunlight cannot penetrate, they found communities of giant tube worms (some as much as 2.4 metres long) clustered around the vent-holes and living in symbiosis with strange bacteria that convert the chemicals spewing out from the vent-holes into a form of food on which the worms live.***




***Almost all life in the sea is dependent on sunlight, which is directly converted into food by microscopic plant-like floating organisms (phytoplankton). Phytoplankton in turn is eaten by animal-like plankton (zooplankton). The plankton supports a succession of actively swimming predators (nekton). Organic debris rains down (dots) and provides food for animals at lower depths. Near-shore organisms are supported by land drainage. Coastal upwelling (upward arrows) provides the phytoplankton with nutrients released by decomposition of organic matter on the bottom. (Organisms not drawn to scale.)***

# World fisheries face growing demand

Most traditionally acceptable species of fish are now fully exploited and many are over-exploited. As a result, the rapid growth in the world catch witnessed in the 1950s and 1960s has given way to a much slower rate of increase. The total catch has averaged around seventy-one million tonnes during the past decade, although the catch of food fish has continued to increase by about 1 per cent per annum. Excluding aquaculture, the final yield from currently exploited species is unlikely to be much more than 110 million tonnes. Production could eventually be increased above this limit, however, by catching so-called unconventional species such as the shrimp-like Atlantic krill, lantern fish, oceanic squid and small pelagic (open sea) fish.

Fisheries in many developing countries are already a vital source of food, employment and income. The changed circumstances of marine fisheries and advances in aquaculture and inland fisheries make it essential, however, to persuade countries accustomed to devoting the bulk of their national resources to agricultural development and the pursuit of industrialization that fisheries are also of considerable value to them.

Fisheries contribute about 6 per cent of the world supply of protein and about 24 per cent of its animal protein, if allowance is made for the use of fishmeal in animal feeds. On a regional basis, the percentage contribution of fish to animal protein in the diet is greatest in Asia. In southeast Asia, for example, 55 per cent of the animal protein consumed is derived from fish. In Africa, the figure is 19 per cent. Such regional statistics reveal little of the true contribution made by fish to food supplies in developing countries; in some communities, often the poorest, it may be the only source of "meat". This dependence on fish is made all the more important because the growth in demand, which is expected to double by the turn of the century, is likely to be greatest in the developing world.

It has been estimated that the fisheries provide employment, some of it part-time, for about sixteen million fishermen in developing countries. Many more people are engaged in associated activities, such as processing and marketing. The greater part of this work force is associated with small-scale or artisanal fisheries. Taking into account dependents, tens of millions in the Third World must rely completely, or in a major way, on fisheries for their livelihood. ■

*Excerpted from:* Fisheries Development in the 1980s,
*Food and Agriculture Organization of the United Nations, Rome*

***Coral of the Great Barrier Reef, off Cairns, Queensland, Australia***

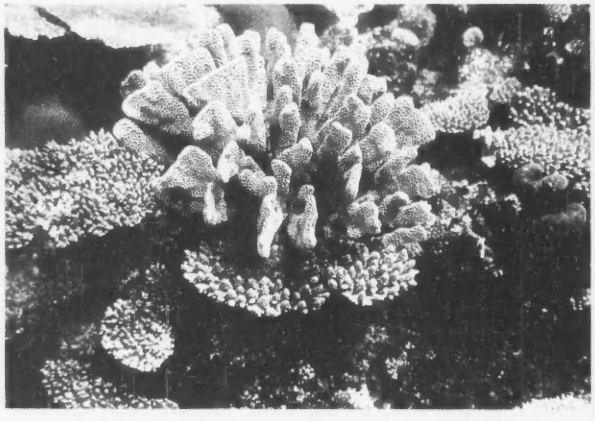


Photo T. Cazalbon © A.A.A. Photo, Paris

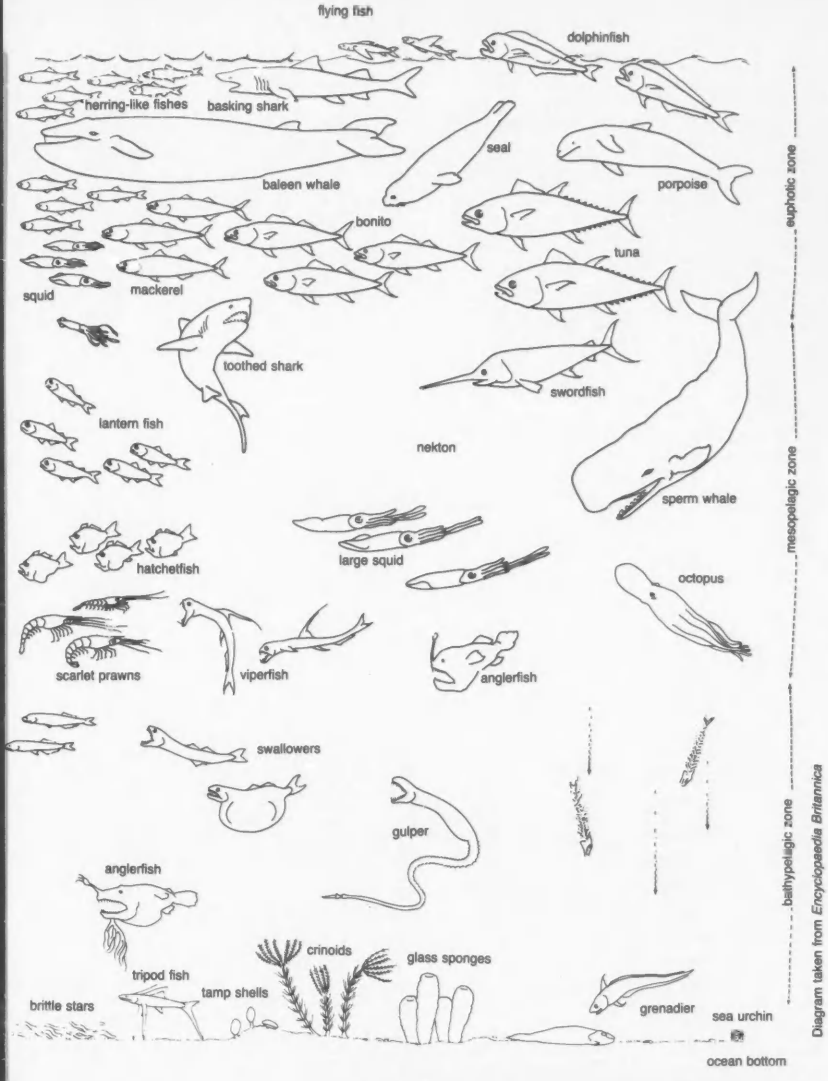



Diagram taken from *Encyclopaedia Britannica*

Photo © APN, Moscow

***A brown sea perch photographed by Soviet researchers in the Tadjoura Rift, Gulf of Aden***

***Below, a fine specimen of a coelacanth. It is known as the "fossil-fish" because until a living specimen was netted in the Indian Ocean during the 1930s experts believed that it had become extinct about seventy million years earlier.***

***This greatly enlarged photo reveals the beauty of the "peacock's tail" of the common algae.***

***A Bahreini pearl-trader displays his wares.***

Photo © Saïdi, Paris

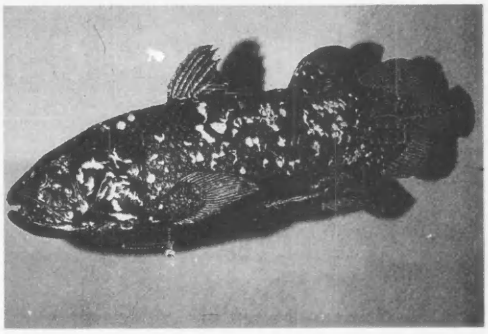


Photo © Jacana, Paris

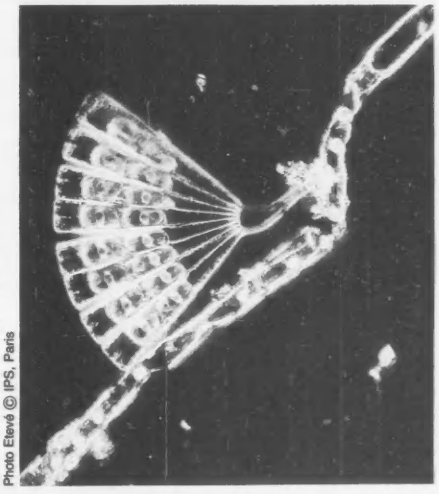


Photo Etevé © IPS, Paris

CONTINUED FROM PAGE 32

Ancient Egyptians and the peoples of Mesopotamia used extracts obtained from seaweed, certain molluscs and the tissue of venomous fish for medical purposes. Research into the possible medical properties of marine organisms continues throughout the world today. In the USSR, for example, advanced research is being carried out by the Institute of Scientific Research on Oceanography and Marine Pisciculture.

The marine organisms that hold out the greatest promise for medicine are molluscs (substances that can be used to regulate the circulation of the blood have been extracted from certain species), sea-urchins, *asteriidae* (starfish), *beroida* (comb-jellies), sea-anemones and certain species of fish.

Already preparations extracted from *myxinii*, a sub-order of fish (slime eels and hagfish) found in the Pacific, are being used as heart stimulants capable of restoring normal functioning of the cardiac muscle, and a product obtained from the tissues of the *ostracion* (box-fish or coffer-fish) has proved its worth as a powerful local anaesthetic. Study of corals seems likely to produce spectacular results. Corals contain active substances which can affect the functioning of the heart and blood vessels, regulate metabolism, increase arterial pressure and prevent thrombosis and cerebral congestion.

The rarer creatures of the ocean also form a living natural history museum, a treasure-store of knowledge which we have only begun to explore and which holds the keys to the origins and evolution of the flora and fauna of the oceans.

Imagine, for example, the astonishment of South African ichthyologist J.B.L. Smith when, in 1938, asked to identify from a sketch an unknown species of fish recently netted in the Indian Ocean, he found himself looking at a drawing of a "living fossil", a coelacanth, a fish with large coarse scales and four limb-like fins that is thought to be the ancestor of four-legged terrestrial vertebrates.

The fossil record shows that the coelacanth, a member of the *crossopterygii* sub-order, dates back some 300 million years and scientists had long believed it to have been extinct for fifty to seventy million years. Smith began to search for further specimens, but it was not until 1952 that other coelacanths were netted off the Comoros Islands.

The discovery of the coelacanth spurred scientists on to search for other, perhaps unknown, creatures that might exist in the ocean depths. Their efforts were rewarded when, in 1952, the Danish research ship *Galatea* fished up a *neopilina* from a depth of 3,580 metres in the Pacific off the coast of Costa Rica. The *neopilina* is a primitive marine mollusc previously thought to have become extinct some 350 million years ago. It forms the link in the evolutionary chain between marine worms and molluscs.

Also during the 1950s, Soviet scientists aboard the research vessel *Vityaz* brought up from the depths (10,500 metres) of the Kuril-Kamchatka Trench a number of worm-like creatures, one of which proved to be of a hitherto unknown type having no digestive tube.

To these remarkable discoveries must be added those made in 1977 by United States researchers on the floor of the Pacific. Diving to depths of some two and a half kilometres, near the Galapagos Islands, in the mini-submarine *Alvin*, they found themselves in an area where the water temperature was as high as 17 degrees centigrade. When they returned to the surface they found that the water samples they had taken smelled strongly of hydrogen sulphide. The water had clearly seeped into cracks in the ocean floor, circulating deep into hot rock and leaching out chemicals from the rock before emerging again heated up to an extremely high temperature.

Hydrogen sulphides are toxic to higher animals, but specific bacteria are immune to its poisonous properties and, indeed, base their metabolism upon it. Thus, in the abyssal deeps of the ocean these bacteria form the first link in a food chain which supports thriving communities of submarine creatures—giant tube-worms, clams, snails and sulphur-coloured mussels.

Down in the almost total darkness of the ocean depths, where the sun's rays do not penetrate, life is based not on photosynthesis which is powered by energy from the sun, but on a process called chemosynthesis which is fuelled by the chemical energy in inorganic compounds. Herein, perhaps, lies the secret of the origin of life on this planet.

The ocean belongs to the whole of humanity. It is the last frontier whose exploration and exploitation is the concern of all the nations. It has already yielded up many of its secrets, but many, many more remain to be unveiled. ■

**VITALI VOITOV**, *of the USSR, is a geographer who has taken part in some forty research expeditions in the Pacific, Atlantic and Indian Oceans. He is the author of 160 books and scientific studies on oceanography, many of which have been translated into English, French, Italian and German. They include:* The Research Ship Vityaz*;* Prospects for Oceanographic Research *(written in collaboration with A. Monine, corresponding member of the USSR Academy of Sciences);* The Mystery of the Bermuda Triangle*; and* The Bounty of the Ocean.

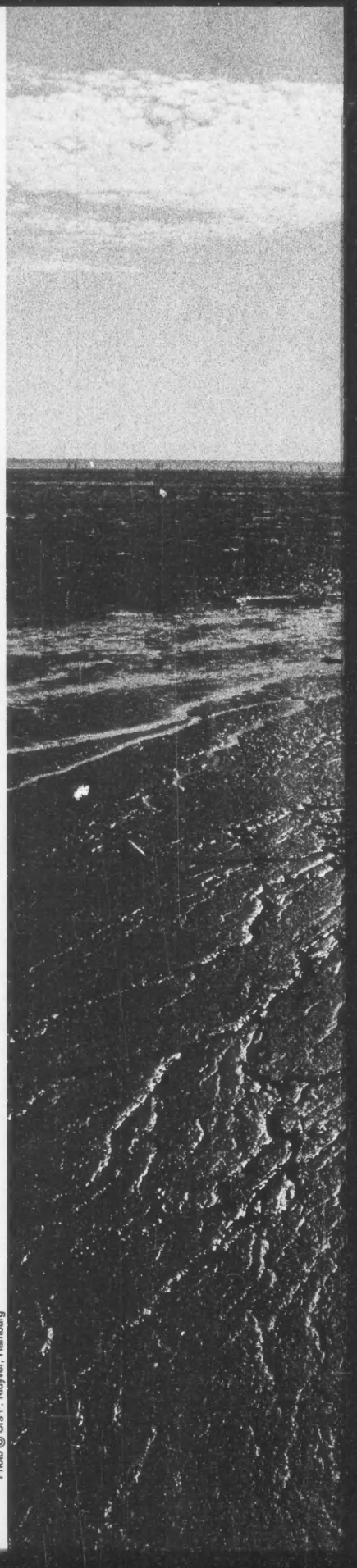


Photo © Urs F. Kluyver, Hamburg

# Year of peace: 2

## The fortress of the Slovenes

Slovenj Gradec, a little Slovenian town of 8,000 people in northwest Yugoslavia, lies at the crossroads of Central Europe, the Balkans and the Mediterranean. It has a long history. A Celtic, then a Roman colony in ancient times, it owes its name— "the fortress of the Slovenes"—to the presence of Slavs there since the tenth century. During the Second World War, this mountainous, forested site was the scene of fierce fighting between partisans and the Nazi occupying forces. The last battle in the European theatre actually took place at nearby Poljana on 15 May 1945, a week after the armistice had been signed.

As a result of all its sufferings, Slovenj Gradec today wishes to be a centre of peace and understanding between cultures. Among its honorary citizens are two internationally renowned sculptors, Henry Moore (born 1898) and Ossip Zadkine (1890-1967).

In 1965, the United Nations sponsored a series of international exhibitions in the vast modern gallery at Slovenj Gradec, and in 1985 the little town organized an exhibition of woodcuts to celebrate the fortieth anniversary of the foundation of the United Nations. One of the most striking exhibits was the work of a local naive painter, J. Tisnikar, an employee at the municipal hospital. The director of the hospital, a committed pacifist, also took part in the event by sponsoring a round table of specialists on medicine for peace.

From 11 to 14 November 1985, a meeting of writers and journalists from nine countries was held at Slovenj Gradec under the auspices of Unesco and the United Nations. At the end of the symposium, entitled "Pen for Peace", all the participants stressed that real solidarity can exist between nations, transcending simplistic political divergences, and that the writer in all circumstances should seek the truth, which is not the exclusive apanage of any individual, society, or State. Unesco was also asked to encourage the translation and publication, in the major world languages, of anti-war literary works from small countries.

**Bogdan Pogachnik**

## The PEN Club and peace

The PEN Club groups between 10,000 and 11,000 writers from all over the world and has 83 Centres in 57 countries. In 1983 it created a Writers for Peace Committee to define the responsibilities of writers and decided that each year 3 March would be celebrated as Writers for Peace Day. All PEN Centres pledge to hold a meeting on that day and to examine the problems that arise in their respective countries. A meeting of this kind was held last year at Tel Aviv in which Israeli and Arab writers took part. It gave rise to lively exchanges of opinion, but was also highly constructive.

Under the aegis of the chairman of this special Committee, a meeting was also held at Bled in Yugoslavia on the theme of the myth of the hereditary enemy. It cannot be denied that literature has created or contributed to the creation of myths of this type. The participants considered that it was time to react and to explode this myth once and for all by studying how it has been formed through literature—which remains one of the great vehicles of contemporary sensibility. The work of this meeting was considered to be so important that the Committee has suggested that the United Nations publish a book on this theme in 1986 on the occasion of the International Year of Peace.

The theme of the 48th International PEN Congress, held in New York from 11 to 17 January was imagination of the State, imagination of the writer. Later this year, a meeting will be held in Hamburg on the theme of contemporary history and its image in literature. ■

**Editorial, Sales and Distribution Office :**
Unesco, 7 Place de Fontenoy, 75700 Paris.

**Subscription rates**
1 year: 78 French francs. 2 years (valid only in France): 144 French francs. Binder for a year's issues : 56 FF
The **UNESCO COURIER** is published monthly.
Individual articles and photographs not copyrighted may be reprinted providing the credit line reads "Reprinted from the **UNESCO COURIER**", plus date of issue, and three voucher copies are sent to the editor. Signed articles reprinted must bear author's name. Non-copyright photos will be supplied on request. Unsolicited manuscripts cannot be returned unless accompanied by an international reply coupon covering postage. Signed articles express the opinions of the authors and do not necessarily represent the opinions of UNESCO or those of the editors of the **UNESCO COURIER**. Photo capitions and headlines are written by the Unesco Courier staff. The boundaries on maps published in the magazine do not imply official endorsement or acceptance by Unesco or the United Nations. The Unesco Courier is produced in microform (microfilm and/or microfiche) by : Unesco, 7 Place de Fontenoy, 75700 Paris; (2) University Microfilms (Xerox), Ann Arbor, Michigan 48100, U.S.A.; (30 N.C.R. Microcard Edition, Indian Head, Inc., 111 West 40th Street, New York, U.S.A.; (4) Bell and Howell Co., Old Mansfield Road, Wooster, Ohio 44691, U.S.A.

**Editorial staff (Paris)**
**Assistant Editor-in-chief :** Olga Rödel
**Managing Editor :** Gillian Whitcomb
**Editors :**
English :
Roy Malkin
French : Alain Lévêque
Neda el Khazen
Spanish : Francisco Fernandez-Santos
Jorge Enrique Adoum
Russian : Nikolai Kuznetsov
Arabic : Sayed Osman
Braille : Frederick Potter

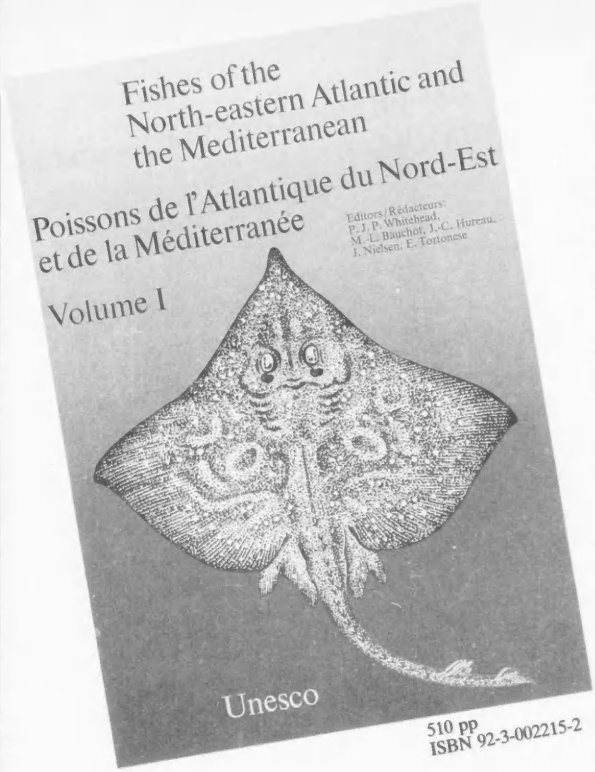
**Research :** Christiane Boucher
**Illustrations :** Ariane Bailey
**Layout and Design :** Georges Servat
**Promotion :** Fernando Ainsa
**Special projects :** Peggy Julien

*All correspondence should be addressed to the Editor-in-Chief in Paris*

**Non-Headquarters editions**
German : Werner Merkli (Berne)
Japanese : Seiichiro Kojima (Tokyo)
Italian : Mario Guidotti (Rome)
Hindi : Rajmani Tiwari (Delhi)
Tamil : M. Mohammed Mustafa (Madras)
Hebrew : Alexander Broido (Tel Aviv)
Persian :
Dutch : Paul Morren (Antwerp)
Portuguese : Benedicto Silva (Rio de Janeiro)
Turkish : Mefra Ilgazer (Istanbul)
Urdu : Hakim Mohammed Said (Karachi)
Catalan : Joan Carreras i Marti (Barcelona)
Malaysian : Azizah Hamzah (Kuala Lumpur)
Korean : Paik Syeung-Gil (Seoul)
Swahili : Domino Rutayebesibwah (Dar-es-Salam)
Croato-Serb, Macedonian, Serbo-Croat, Slovene : Bozidar Perkovic(Belgrade)
Chinese : Shen Guofen (Beijing)
Bulgarian : Goran Gotev (Sofia)
Greek : Nicolas Papageorgiou (Athens)
Sinhala : S.J. Sumanasekera Banda (Colombo)
Finnish : Marjatta Oksanen (Helsinki)
Swedish : Inger Raaby (Stockholm)
Basque : Gurutz Larrañaga (San Sebastian)
Thai : Savitri Suwansathit (Bangkok)



IMPRIMÉ EN FRANCE (Printed in France) - Dépôt légal : C 1 - Février 1986 - Commission paritaire N° 27.253 - Diffusé par les N.M.P.P.
PHOTOCOMPOSITION : Ateliers de l'UNESCO - PHOTOGRAVURE-IMPRESSION : MAURY-IMPRIMEUR S.A., Z.I. route d'Etampes, 45330 MALESHERBES.




**Fishes of the North-eastern Atlantic and the Mediterranean** is an important new reference work which describes the main taxonomic features and biology of all the known marine fishes of the north-eastern Atlantic and Mediterranean region—a total of 1,256 species from 218 families. Twenty years in the making, the guide has been prepared by an international team of specialists (with contributions from over 70 authors) and is being published by Unesco in 3 volumes over the period 1984-1986. Volume I is now available.

Preface, Foreword and User's Guide are in both English and French. The main text is in English only. Common names of each species are given in various languages, as known.

**FNAM** will be of great value for many years to come to workers in many disciplines, such as marine biology, oceanography and fisheries science, as well as to those concerned with the marine aspects of zoogeography, physiology, embryology and parasitology. All libraries and laboratories, museums and universities will need a set on their shelves.

**FNAM** can be purchased with local currency through academic booksellers worldwide (see list of suppliers of Unesco publications below). Local prices may be obtained from your bookseller. However three sample prices for Volume I are as follows:

250 FF at the
Unesco Bookshop
7 Place de Fontenoy,
75700 Paris

United Kingdom: £37.50
HMSO
P.O. Box 276
London SW8 5DT

United States $63.50
(plus relevant sales tax),
Unipub
P.O. Box 1222
Ann Arbor, MI 48106

# Where to renew your subscription

## and place your order for other Unesco publications

**Order from any bookseller or write direct to the National Distributor in your country. (See list below; names of distributors in countries not listed, along with subscription rates in local currency, will be supplied on request.)**

**AUSTRALIA.** Hunter Publications, 58A Gipps Street, Collingwood Victoria 3066; Publications: Educational Supplies Pty. Ltd. P.O. Box 33, Brookvale, 2100, NSW. Periodicals: Dominie Pty. Subscriptions Dept , P.O. Box 33, Brookvale 2100, NSW. Subagent: United Nations Association of Australia, P.O. Box 175, 5th floor, Ana House, 28 Elizabeth Street, Melbourne Victoria 3000. **AUSTRIA.** Buchhandlung Gerold and Co., Graben 31, A-1011, Vienna. **BAHAMAS.** Nassau Stationers Ltd., P.O. Box N-3138, Nassau. **BANGLADESH.** Bangladesh Books International Ltd., Ittefaq Building, 1, R.K. Mission Rd., Hatkhola, Dacca 3. — **BARBADOS.** University of the West Indies Bookshop, Cave Hill Campus, P.O. Box 64, Bridgetown. **BELGIUM.** "Unesco Courier" Dutch edition only: N.V. Handelmaatschappij Keesing, Keesinglaan 2-18, 2100 Deurne-Antwerpen. French edition and general Unesco publications agent: Jean de Lannoy, 202, avenue du Roi, 1060 Brussels, CCP 000-0070823-13. **BOTSWANA.** Botswana Book Centre, P.O. Box 91, Gaborone. **BURMA.** Trade Corporation No. 9, 550-552 Merchant Street, Rangoon. **CANADA.** Renouf Publishing Co. Ltd., 2182 St. Catherine Street West, Montreal, Que. H3H 1M7. **CHINA.** China National Publications Import and Export Corporation, P.O. Box 88, Beijing. **CYPRUS.** "MAM", Archbishop Makarios 3rd Avenue, P.O. Box 1722, Nicosia. **CZECHOSLOVAKIA.** — S.N.T.L., Spalena 51-113 02, Prague 1; Ve Smeckach 30, P.O.B. 790 - 111 - 27 Prague 1 (Permanent display); Zahranicni literatura, 11 Soukenicka, Prague 1. For Slovakia only: Alfa Verlag. — Publishers, Hurbanovo nam. 6,893 31 Bratislava — CSSR. **DENMARK.** Munksgaard Export-OG Tidsskriftservice 35 Norre Sogade, DK-1970 Kobenhavn K. **EGYPT (ARAB REPUBLIC OF).** National Centre for Unesco Publications, No. 1 Talaat Harb Street, Cairo. **ETHIOPIA.** National Agency for Unesco, P.O. Box 2996, Addis Ababa. **FINLAND.** Akateeminen Kirjakauppa, Keskuskatu 1, SF-00100 Helsinki 10; Suomalainen Kirjakauppa Oy, Koivuvaarankuja 2, 01640 Vantaa 64. **FRANCE.** Librairie de l'Unesco, 7, place de Fontenoy, 75700 Paris, C.C.P. 12598-48. **GERMAN DEMOCRATIC REP.** Buchhaus Leipzig, Postfach 140, 710 Leipzig or from Internationalen Buchhandlungen in the G.D.R. **FED. REP. OF GERMANY.** For the Unesco Courier (German, English, French and Spanish editions): Mr. H. Baum, Deutscher Unesco-Kurier Vertrieb, Basalstrasse 57, D-5300 Bonn 3. For other Unesco publications: Karger Verlag, Germering/München. For scientific maps only: Geo Center, Postfach 800830, Stuttgart 80. **GHANA.** Presbyterian Bookshop Depot Ltd., P.O. Box 195, Accra; Ghana Book Suppliers Ltd., P.O. Box 7869, Accra; The University Bookshop of Ghana, Accra; The University Bookshop of Cape Coast; The University Bookshop of Legon, P.O. Box 1, Legon. **GREAT BRITAIN.** See United Kingdom. **HONG KONG.** Federal Publications (HK) Ltd., 5A Evergreen Industrial Mansion, 12 Yip Fat Street, Aberdeen. Swindon Book Co., 13-15, Lock Road, Kowloon. Hong Kong Government Information Services, Publication Centre, Baskerville House, 22 Ice Street. **HUNGARY.** Kultura-Bushimport - ABT, P.O.B. 149 - H-1389, Budapest 62. **ICELAND.** Snaebjörn Jonsson & Co., H.F., Hafnarstraeti 9, Reykjavik. **INDIA.** Orient Longman Ltd., Kamani Marg, Ballard Estate, Bombay 400038; 17 Chittaranjan Avenue, Calcutta 13; 36a, Anna Salai, Mount Road, Madras 2; 5-9-41/1 Bashir Bagh, Hyderabad 500001 (AP); 80/1 Mahatma Gandhi Road, Bangalore-560001; 3-5-820 Hyderguda, Hyderabad-500001. Sub-Depots: Oxford Book & Stationery Co. 17 Park Street, Calcutta 70016; Scindia House, New Delhi; Publication Unit, Ministry of Education and Culture, Ex. AFO Hutments, Dr. Rajendra Prasad Road, New Delhi 110001. **INDONESIA.** Bhratara Publishers and Booksellers, 29 Jl. Oto Iskandardinata III, Jakarta; Indira P.T., Jl Dr Sam Ratulangie 37, Jakarta Pusat. **IRAN.** Kharazmie Publishing and Distribution Co., 28, Vessal Shirazi Street, Enghélab Avenue. P.O. Box 314/1486, Teheran; Iranian Nat. Comm. for Unesco. 1188 Enghlab Av., Rostam Give Building, Zip Code 13158, P.O. Box 11365-4498, Teheran. **IRAQ.** McKenzie's Bookshop, Al Rashid Street, Baghdad. **IRELAND.** The Educational Company of Ireland Ltd, Ballymount Road, Walkinstown, Dublin 12. **ISRAEL.** A.B.C. Bookstore Ltd., P.O. Box 1283, 71 Allenby Road, Tel Aviv 61000. **ITALY.** Licosa (Libreria Commissionaria Sansoni, S.p.A.) Via Lamarmora 45, Casella Postale 552, 50121 Florence. **JAMAICA.** Sangster's Book Stores Ltd., P.O. Box 366, 101 Water Lane, Kingston. University of the West Indies Bookshop, Mona, Kingston. **JAPAN.** Eastern Book Service Inc., 37-3 Hongo 3-chome Bunkyo-ku Tokyo 113. **KENYA.** East African Publishing House, P.O. Box 30571, Nairobi; Africa Book Services Ltd., Quran House, Mfangano Street, P.O. Box 45245, Nairobi. **KOREA.** Korean National Commission for Unesco, P.O. Box Central 64, Seoul. **KUWAIT.** The Kuwait Bookshop Co., Ltd, POB 2942, Kuwait; for the Unesco Courier; Farafalla Press Agency, P.O. Box SAFA 4541, Kuwait. **LESOTHO.** Mazenod Book Centre, P.O. Mazenod, Lesotho, Southern Africa. **LIBERIA.** Code and Yancy Bookshops Ltd., P.O. Box 286, Monrovia. **LIECHTENSTEIN :** Eurocan Trust Reg. P.O.B. 5 - 9494 Schaan. **LIBYA.** Agency for Development of Publication & Distribution, P.O. Box 34-35, Tripoli. **LUXEMBOURG.** Librairie Paul Bruck, 22, Grande-Rue, Luxembourg. **MALAWI.** Malawi Book Service, Head Office, P.O. Box 30044 Chichiri, Blantyre 3. **MALAYSIA.** University of Malaya Cooperative Bookshop, Kuala Lumpur 22-11. **MALTA.** Sapienzas, 26 Republic Street, Valletta. **MAURITIUS.** Nalanda Company Ltd., 30, Bourbon Street, Port-Louis. **MONACO.** British Library, 30 bd. des Moulins, Monte-Carlo. **NEPAL.** Sajha Prakashan Polchowk, Kathmandu. **NETHERLANDS.** KEESING BOEKEN B.V., Joan Muyskenweg, 22, Postbus 1118, 1000 BC Amsterdam. **NETHERLANDS ANTILLES.** Van Dorp-Eddine N.V., P.O. Box 200, Willemstad, Curaçao. N.A. **NEW ZEALAND.** Government Printing Office, Government Bookshops at: Rutland Street, P.O. Box 5344, Auckland; 130, Oxford Terrace. P.O. Box 1721 Christchurch; Alma Street, P.O. Box 857 Hamilton; Princes Street, P.O. Box 1104, Dunedin, Mulgrave Street, Private Bag, Wellington. **NIGERIA.** The University Bookshop of Ife; The University Bookshop of Ibadan, P.O. 286; The University Bookshop of Nsukka; The University Bookshop of Lagos; The Ahmadu Bello University Bookshop of Zaria. **NORWAY.** Johan Grundt Tanum, P.O.B. 1177 Sentrum - Oslo 1, Narvesen A/S; Subscription and Trade Book Service. P.O.B. 6125 Etterstad, Oslo 6; Universitets Bokhandelen, Universitetssentret, Postboks 307 Blindern, Oslo 3. **PAKISTAN.** Mirza Book Agency, 65 Shahrah Quaid-i-azam, P.O. Box No. 729, Lahore 3; Unesco Publications Centre, Regional Office for Book development in Asia and the Pacific, 39 Delhi Housing Society, P.O. Box 8950, Karachi 29. **PHILIPPINES.** National Book Store, Inc. 701, Rizal Avenue, Manila D-404. **POLAND.** Orpan-Import, Palac Kultury i Nauki, Warsaw; Ars Polona-Ruch, Krakowskie Przedmiescie No. 7.00-068 WARSAW. **PORTUGAL.** Dias & Andrade Ltda. Livraria Portugal, rua do Carmo 70, Lisbon. **SEYCHELLES.** National Bookshop, P.O. Box 48, Mahé; New Service Ltd., Kingsgate House, P.O. Box 131, Mahé. **SIERRA LEONE.** Fourah Bay, Njala University and Sierra Leone Diocesan Bookshops, Freetown. **SINGAPORE.** Federal Publications (S) Pte Ltd. Times Jurong, 2 Jurong Port Road, Singapore 2261. **SOMALI DEMOCRATIC REPUBLIC.** Modern Book Shop and General, P.O. Box 951, Mogadiscio. **SOUTH AFRICA.** For the Unesco Courier (single copies) only: Central News agency, P.O. Box 1033, Johannesburg. **SRI LANKA.** Lake House Bookshop, 100 Sir Chittampalam Gardiner Mawata P.O.B. 244 Colombo 2. **SUDAN.** Al Bashir Bookshop, P.O. Box 1118, Khartoum. **SWEDEN.** All publications A/B.C.E. Fritzes Kungl. Hovbokhandel, Regeringsgatan 12, Box 16356, 10327 Stockholm 16. For the Unesco Courier: Svenska FN Förbundet, Skolgrand 2, Box 150 50 S- 104 65, Stockholm; Wennergren-Williams, Box 30004-S-104, 25 Stockholm; Esselte Tidskriftscentralen, Gamla Brogatan 26, Box 62 - 101 20 Stockholm. **SWITZERLAND.** All publications: Europa Verlag, 5 Ramistrasse, Zurich. Librairie Payot, rue Grenus 6, 1211, Geneva 11, C.C.P. 12-236. Librairies Payot also in Lausanne, Basle, Berne, Vevey, Montreux, Neuchâtel and Zurich. **TANZANIA.** Dares Salaam Bookshop, P.O.B. 9030 Dar-es-Salaam. **THAILAND.** Nibondh and Co. Ltd., 40-42 Charoen Krung Road, Siyaeg Phaya Sri, P.O. Box 402; Bangkok: Suksapan Panit, Mansion 9, Rajdamnern Avenue, Bangkok; Suksit Siam Company, 1715 Rama IV Road, Bangkok. **TRINIDAD AND TOBAGO.** National Commission for Unesco, 18 Alexandra Street, St. Clair, Trinidad, W.I. **TURKEY.** Haset Kitapçvi A.S., Istiklâl Caddesi, N° 469, Posta Kutusu 219, Beyoglu, Istambul. **UGANDA.** Uganda Bookshop, P.O. Box 7145, Kampala. **UNITED KINGDOM.** H.M. Stationery Office, H.M.S.O., P.O. Box 276, London, SW8 5DT, and Govt. Bookshops in London, Edinburgh, Belfast, Manchester, Birmingham, Bristol; for scientific maps only: McCarta Ltd., 122 King's Cross Road, London WC 1X 9 DS. **UNITED STATES.** Unipub, 205 East 42nd Street, New York, N.Y. 10017. Orders for books & Periodicals: P.O. Box 1222, Ann Arbor, MI 48106. **U.S.S.R.** Mezhdunarodnaya Kniga, Moscow, 121200. **YEMEN.** 14th October Corporation, P.O. Box 4227, Aden. **YUGOSLAVIA.** Mladost, Ilica 30/11, Zagreb; Cankarjeva Zalozba, Zopitarjeva 2, Lublijana; Nolit, Terazije 27/11, Belgrade. **ZAMBIA.** National Educational Distribution Co. of Zambia Ltd., P.O. Box 2664 Lusaka. **ZIMBABWE.** Textbook Sales (PVT) Ltd., 67 Union Avenue, Harare.